Predictors of Transitional Phase Success In

Visual Communication Design Education

by

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ABSTRACT

Traditional design education consists of three phases: perceptual, transitional, and professional. This study explored three independent variables (IVs) as predictors of success in the Transitional Phase of a visual communication design (VCD) program: (a) prior academic performance (as reported by GPA); (b) cognitive style (assessed with Peterson, Deary, and Austin's Verbal Imagery Cognitive Styles Test [VICS] and Extended Cognitive Style Analysis-Wholistic Analytic Test [E-CSA-WA]); and (c) learning style (assessed with Kolb's Learning Style Inventory [LSI] 3.1).

To address the research problem and hypothesis, this study examined (a) the relationship between academic performance, cognitive style, and learning style, and visual communication design students' performance in the Transitional Phase; (b) the cognitive style and learning style preferences of visual communication design students as compared with other samples; and (c) how the resulting knowledge can be used to improve instructional design for the Transitional Phase in VCD programs.

Multiple regression analysis revealed that 9% of Transitional Phase performance was predicted by studio GPA. No other variables were statistically significant predictors of Transitional Phase performance. However, ANOVA and *t* tests revealed statistically significant and suggested relationships among components of the independent variables, that indicate avenues for future study. The results are discussed in the context of style-based learning theory, and the cognitive apprenticeship approach to instructional design.

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GLOSSARY OF TERMS

ANOVA: "analysis of variance," a statistical method for making simultaneous comparisons between two or more means, to determine whether a significant relation exists between variables

Behaviorism: a theory of learning based on observable changes in behavior, behaviorism focuses on a new behavioral pattern being repeated until it becomes automatic

Bootstrapping: statistical methods that emulate a larger original sample and allow the significance of a test statistic to be estimated when parametric assumptions cannot be honored; bootstrapping creates an estimate of a population parameter by using *resampling* to draw many repeated samples from the original data set

Cognitive dissonance: mental dissonance resulting from an anticipated result and sensory or cognitive information that contradicts that anticipation

Cognitive style: inbuilt and persistent preferences in experiencing, perceiving, recalling, organizing, mentally representing, and processing information; closely related to ability

Cognitivism: a theory of learning based on the thought processes behind the behavior; changes in behavior are observed, and used as indicators of what is happening inside the learner's mind

Collinearity (multicollinearity): a problem arising in multiple regression analysis when independent variables are highly correlated, resulting in unreliable regression coefficients; one remedy is simply to remove one of the collinear variables from the regression equation

Construct: any complex psychological concept; examples would be: motivation, anger, personality, intelligence, love, fear, etc; constructs may be constituents of theories, models, or conceptual frameworks; constructs must be *operationalized* (i.e. represented the form of an empirically testable item) in order to be measured

Constructivism: a theory of learning based on the premise that people construct their own perspective of the world through individual experiences and schema; constructivism focuses on self-directed learning and preparing the learner to problem-solve in ambiguous situations

Construct Validity: empirical agreement between a theoretical concept and a specific measuring device or procedure; construct validity can be broken down into two sub-categories: content validity—the extent to which a measurement reflects or encompasses the specific intended domain of content, and criterion related validity (also referred to as instrumental validity)—the accuracy of a measure or procedure compared with another measure or procedure which has demonstrated validity

Critical thinking: a comprehensive approach to thought and assessing statements, with parallels to metacognitive approaches—"thinking about thinking;" the concept has roots in analytic philosophy and pragmatist constructivism, as well as in the Buddhist Teachings of the kalamasutta and abhidhamma, and the Greek Socratic tradition

Cronbach's alpha: a statistic commonly used to estimate the internal consistency reliability of a psychometric test score for a sample of examinees

Curriculum: the courses offered by an educational institution, or a set of courses constituting an area of specialization

Deep learning: learning that focuses on a rich understanding of subject matter, the nature of knowledge, critical thinking, and cognitive sophistication

Development: the transformation of "undifferentiated, unspecialized cognitive abilities into cognitive competence and problem-solving skill" (Driscoll, 2000, p. 171), as distinguished from, *learning*, *change*, or *growth*; development is qualitative rather than quantitative improvement

Dialectic: a method of argument, or structure of thought, for resolving disagreement, usually presented in a threefold manner characterized by the stages of thesis, antithesis, and synthesis

Domain: a discipline, such as art, business, education or science

Dummy variables: a numerical variable used in regression analysis to represent subgroups of the sample in a study; the subgroups are distinguished from each other by assigning either a 1 or a 0 to members of the subgroup or condition; dummy variables enable researchers to use a single regression equation to represent multiple groups

E-CSA-WA: Extended Cognitive Style Analysis-Wholistic Analytic test, a revision of Riding's Cognitive Styles Analysis, wholist-analytic subtest, developed by Peterson, Deary, and, Austin (2003); see also *VICS*;

Ecological Validity: the degree to which the behaviors observed and recorded in a study reflect the behaviors that actually occur in natural settings; it is also associated with "generalizability," there is usually a trade-off between experimental control and ecological validity

Education: a process that incorporates three things:

Instruction: "any deliberate arrangement of events to facilitate a learner's acquisition of some goal."

Teaching: the direct interaction between a learner and the agent of the instruction—professor, interactive media, textbook, etc., and

Learning: "a persisting change in performance or performance potential as a result of interaction with the learner's environment." In order to be considered learning, this change must be demonstrable in some empirical fashion (Driscoll, 2000, p. 25, 9)

Effect size: a measure of difference or gain in a statistical test; effect sizes of less than

0.2 are usually considered trivial, between 0.2 to 0.5 small, between 0.5 and 0.8 moderate, and 0.8 or more, large

Equivalency reliability: the extent to which two items measure identical concepts at an identical level of difficulty

External validity: the degree to which conclusions from a sample can be generalized to a population, to other subject populations, to other settings, or to other time periods; when a sample is non-random in unknown ways, the likelihood of external validity is low

F distribution (*F* test): any statistical test in which the test statistic has an *F*-distribution under the null hypothesis; most often used when comparing statistical models in order to identify the model that best fits the population from which data were sampled

Face Validity: the degree to which a measure or instrument appears ("on the face of it") to measure the theoretical concept that it purports to measure

Field Dependent/Independent (FDI): a dimension of cognitive style identified by Witkin (1962) that was the predecessor and basis of Riding and Cheema's (1991) Holist-Analytic dimension

Graphic design: (see Visual Communication Design) an anachronism for *visual communication design*; other outdated designations include "commercial art" and "graphics"

Hegelian dialectic: see "Dialectic"

Homoscedasticity: literally, "same scatter," a scatterplot or residual plot depicts homoscedasticity if the scatter on any vertical slice through the plot does not vary significantly from any other; in regression analysis it is the condition of constant variance

Ill-defined problem: problems for which there are various assumptions, evidence, and opinions, that may lead to a variety of solutions; these are the types of problems most frequently encountered in VCD and other design problem-solving

Instructional Design (ID): a program for teaching and learning, usually involving (a) determining the current state and needs of the learner, (b) defining the goals of instruction, (c) creating an intervention to meet those goals, and (d) evaluating the consequences

Instrument: questionnaires, tests, and other empirical means of assessment

Internal Consistency: the extent to which tests or procedures assess the same characteristic, skill or quality

inter-subject: comparison of data from one subject or case to that of other subjects or cases

Interval (level or scale): similar to an ordinal scale, but in which the values have equal intervals between them; Celsius temperature is an example

intervention: (in the context of instructional design) a procedure that introduces a teaching technique, or project that is designed to address specific learning objectives

intra-subject: comparisons among subsets of data from a single subject or within a single case

Inventory: a list of traits, preferences, attitudes, interests, or abilities used to evaluate personal characteristics or skills

Ipsative scoring: respondents compare two or more options and pick one which is most preferred (sometimes called a “forced choice” scale); the resulting scores only represent the relative values of the individual being tested and are not comparable across individuals; such tests typically ask people to “describe themselves,” and are not usually appropriate for recruitment and selection (see also “normative scoring”)

Kurtosis: refers to the “peakedness” of a distribution; if values pile up narrowly the distribution is said to be *leptokurtic*, if the values are more dispersed the distribution is *platykurtic*

Level (or scale) of measurement: Four types of measurement proposed by Stevens (1946): nominal, ordinal, interval, and ratio (see individual entries for definitions); The words “continuous” or “scale” refer to interval, or ratio data

Likert scale: respondents choose the score (e.g. 1 to 5) which best represents the degree to which they agree with a given statement

Linearity, or linear association: a relationship between a distribution of two variables that can be best represented by a straight line; Two variables are linearly associated if a change in one is associated with a proportional change in the other; The degree of association is reported by a correlation coefficient of -1 to 1

Measure: in psychometric testing this may be synonymous with “instrument,” or also refer to a particular component of, or question on, an instrument

Multicollinearity: see collinearity

Multiple regression: a regression equation or analysis in which several independent variables are tested for their association with a dependent variable

Nominal (level or scale): a categorical level of measurement that is “in name only” (e.g. red, blue, yellow); there is no explicit order of value to the items in the scale

Nonprobability sampling: a sampling method that does not involve random selection, and thus cannot depend upon the rationale of probability theory; in social science research there may be circumstances where it is not feasible, or theoretically desirable to do random sampling, such as studying limited and specific populations where generalizing is not a primary interest; nonprobability sampling may be accidental or purposive

Normal distribution, normality: a distribution that conforms to the normal curve; all values are distributed equally around a central mean; symmetric and unimodal

Normative scoring: measures quantifiable characteristics on individual scales that can vary independently; the scores can also measure the characteristics of individuals as compared to confirmed patterns of normality, such as particular groups, or populations; normative testing generally has a higher validity than ipsative (see also “ipsative scoring”)

Normative sample: a sample sufficiently large that its statistical characteristics are deemed to represent population parameters (see also standardization sample)

Null hypothesis: a hypothesis that corresponds to the default position that there is no relationship between study variables; similar to the legal presumption that a defendant is innocent until proven guilty; in most research it is adopted as the hypothesis that the evidence will either statistically significantly reject, or not reject as substantiation for the basis of the research

Operationalize: the process of creating empirical measures from constructs

Ordinal (level or scale): a scale in which values can be ordered in terms of different degrees or amounts; however, ordinal scales do not disclose the amount of difference between items; a Likert scale is an example of an ordinal scale

Parameter: a statistical term that summarizes a characteristic of a population, while a *statistic* summarizes a characteristic of a sample; the term also is applied to characteristics that describe the disposition of sets of data or samples (e.g. normality)

Parametric analysis: a statistical analysis that assumes data have come from a probability distribution and makes inferences about the parameters of the distribution; most basic statistical procedures are parametric

Power: the probability that a statistical test will reject the null hypothesis when the null hypothesis is false; in legal terms, if the null hypothesis is that the accused is “innocent until proven guilty,” the lower the power, the more likely that a *guilty* person would *not* be convicted; statistical power depends on (a) the level of statistical significance used in the test, (b) the *effect* size of interest, and (c) the sample size; power analysis can be used to determine the minimum sample size required to detect an effect of a given size, among other methodological issues

Problem types or structures: a classification of structures terms of increasing complexity proposed by Kitchener (1983): well-defined, ill-defined, wicked, and super-wicked (see individual entries for definitions of the foregoing terms)

Psychometric testing (or assessment): the field of study concerned with the theory and technique of educational and psychological measurement, which includes the measurement of knowledge, abilities, attitudes, and personality traits

Purposive sampling: a sampling method that deliberately includes cases that are judged to be typical of a category of interest, or specific predefined group, such as students in a specific class

Ratio (level or scale): a scale that has equal intervals between values (like an interval scale), but with an absolute zero point; the Kelvin temperature scale is an example, as are variables derived from counting

Regression: linear regression, or simple linear regression; a regression equation or analysis in which a single independent variable is tested for its association with a single dependent variable

Reliability: the extent to which an experiment, test, or any measuring procedure yields the same result on repeated trials; there are many types of reliability, including *equivalency*, *internal consistency*, and *test-retest* reliability

Resampling: used in bootstrapping; drawing many repeated samples from an original data set; each drawn sample has the same number of cases as the original, but duplicate cases are randomly selected and included in each repeated sample

Residual: in regression analysis, the difference between the observed value of the dependent variable y and the predicted value x is called the residual e; each data point has one residual ($e = y - x$); Both the sum and the mean of the residuals are equal to zero

Residual plot: a graph that shows the residuals on the vertical axis and the independent variable on the horizontal axis; if the points in the plot are randomly dispersed around the horizontal axis, a linear regression model is appropriate for the data; otherwise, a non-linear model is more appropriate

Response bias: respondents answer questions on a survey or inventory in a way they believe is appropriate rather than according to their true beliefs

R-squared or R^2: the "coefficient of determination," R^2 is a key output of regression analysis; it is interpreted as the proportion of the variance in the dependent variable that is predictable from the independent variable; in simple linear regression, the symbol is r^2, in multiple regression it is R^2; the coefficient of determination is the square of the correlation (r) between predicted Y scores and actual Y scores; thus, it ranges from 0 to 1; with simple linear regression, the coefficient of determination is also equal to the square of the correlation between X and Y scores; an R^2 of 0 means that the dependent variable cannot be predicted from the independent variable; an R^2 of 1 means the dependent variable can be predicted without error from the independent variable; an R^2 between 0 and 1 indicates the extent to which the dependent variable is predictable; an R^2 of 0.10 means that 10 percent of the variance in Y is predictable from X; an R^2 of 0.20 means that 20 percent is predictable, etc.

Scaffolding: the process of a teacher providing sufficient support for learners to perform a task that is too advanced for them to perform independently

Significance: the level of probability, as determined by a statistical test, at which a hypothesis is rejected or retained; usually represented by *p*; typical levels in social science research are $p \leq .05$, or $p \leq .01$

Skew: the extent to which a distribution deviates from normality; in a normal distribution the mean, median, and mode of the distribution are the same value; in a skewed distribution the mean, median, and mode of the distribution are different values; if the values in the distribution trail off to the right it has a “positive” skew, if to the left the skew is “negative”

Split point: the numeric value (usually the median) at which a continuous scale variable is divided to create categories, or categorical variables; in the present study these pertain to variables in cognitive style and learning style models

Stability reliability: see “test-retest reliability”

Statistic: a characteristic of a sample, as contrasted with a *parameter*, which is a characteristic of a population

Stepwise regression: a model building method in which multiple independent variables are introduced one at a time and retained in the model providing they contribute to an increase in the overall statistical significance of the model; Independent variables are entered into the equation based on the descending order of the largest significant correlation coefficient, until an independent variable does not uniquely influence the dependent variable

Style Type: (in the present study) one of four types defined by a person’s joint score on the two dimensions of Kolb’s 1984 Experiential Learning Theory model, as assessed by Kolb’s Learning Style Inventory; or Riding and Cheema’s (1991) Cognitive Style Theory, as assessed by Riding’s Cognitive Style Analysis, or Peterson’s (2005) Cognitive Style Analysis instruments (C-CSA / VICS)

Summative assessment: evaluation of performance carried out at the end of a piece of work

Super-wicked problem: problems that share the attributes of *wicked* problems, with the additional characteristics that (a) time is running out, (b) there is no central authority, and (c) those seeking to solve the problem are also causing it; global climate change is an example

Surface learning: an approach to learning that focuses on what will be assessed and memorizing details

Symmetric distribution: a distribution that can be divided at the center so that each half is a mirror image of the other

Test-retest reliability: the degree to which a test or instrument yields the same results with the same group of subjects over time, sometimes called “stability reliability”

Transitional Phase: the second phase in traditional design studio education that forms a bridge between mechanincal and formal skills, and advanced problem solving and conceptual skills

Unimodal: a distribution with a single mode (most frequent score), or single “hump;” the familiar “bell curve” is an example of a unimodal distribution

Validity: the degree to which a study or instrument accurately reflects or assesses the specific concept that the researcher is attempting to measure; there are many types of validity, including *construct*, *ecological*, *external*, and *face* validity

VICS: Verbal Imagery Cognitive Styles test; a revision of the verbal-imagery subtest of Riding’s Cognitive Styles Analysis, developed by Peterson, Deary, and, Austin (2005); see also *E-CSA-WA*;

Visual Communication Design (VCD): the branch of visual design concerned with the aesthetics and production of layout, design, typography, and communication, undertaken to convey a specific message to a target audience; the field encompasses a variety of disciplines including, print, digital, and interactive design; VCD refers to both the process (designing) by which the communication is created and the products (designs) that are generated

Well-defined problem: problems that have an absolutely correct and knowable solutions (e.g. 2 = 2 = 4)

Wicked problem: problems that are similar to ill-defined problems, but have the additional characteristics that they are essentially a “one shot” opportunity in which each effort at a solution fundamentally modifies the problem definition and is irreversible

(Sources: AlleyDog.com, 2011; American Psychological Association, 2010; Coffield, Moseley, Hall, & Ecclestone 2004a; Coladarci, Cobb, Minium, & Clarke, 2004; Garson, 2010; Green & Salkind, 2005; Groat & Wang, 2002; Merriam-Webster, 2003; Psychometrics West, 2004; StatSoft Inc., 2011; StatTrek.com, 2011; Tabachnick & Fidell, 2001; Trochim, 2006; Wikimedia Foundation, 2011)

1 INTRODUCTION

Background

Noted design educator, Professor Rob Roy Kelly (2001b), observed that undergraduate Visual Communication Design[1] (VCD) curriculum should present three general categories of problems to students: perceptual, transitional, and professional—in that sequence (p. 88). In this model, students begin with foundation courses grounded in perceptual studies, formal values, and craft. Next, students enter a *Transitional Phase* that introduces complex exercises focused on concept development, and integrating information design with the previously learned perceptual skills and craft. The final, professional, stage emphasizes research, problem-solving, self-directed, and collaborative work, in preparation for professional practice.

Figure 1 depicts a version of this model, based on the VCD program at Arizona State University, circa 2006 - 2008. Programs at other institutions may introduce the Transitional Phase at an earlier or later point, while maintaining a similar sequence. The upper part of Figure 1 shows the phases of study, types of problems, and sequence in which they occur. Each of the three stages is additive—students continue to improve upon all previous learning (Davis, 1998; Kelly, 2001b, 2001c; Poggenpohl, 2004). The structure of this model is similar to that of other traditional design education programs such as those in architecture, industrial design, and interior design (McCoy, 1997, 2005; Wilson, 2001). In addition, the lower part of Figure 1 shows the categories of learning theory and knowledge represented in the sequence. These are discussed in detail in “Learning Theory and Instructional Design,” p. 23.

[1] The term “Visual Communication Design” is the contemporary alternative to the traditional term “Graphic Design,” and used throughout this paper. It is widely accepted as a more accurate representation of the current state of the field, which includes print, electronic, and multimedia design practitioners.

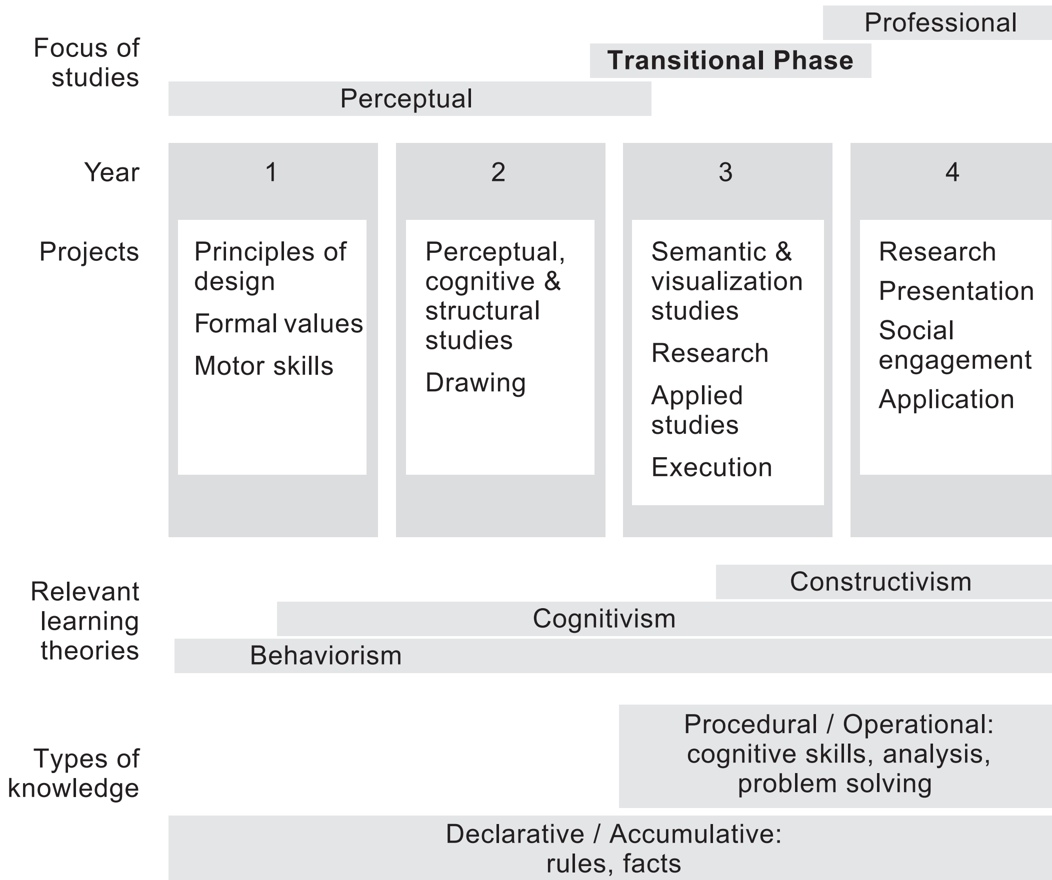

Figure 1. An overview of undergraduate VCD education.

The focus of this thesis is student performance in the Transitional Phase. During the Transitional Phase students frequently express frustration over incorporating quantitative, verbal, and procedural information with the knowledge and craft acquired in their foundation studies. Additionally, transfer of prior knowledge appears to be hampered by the complexity and novelty of the transitional projects. These challenges “raise a key issue” in the transition to applied problem-solving and professional practice in VCD education (K. Hiebert, personal communication, May 31, 2006; Kelly, 2001b, 2001c).

Since the Transitional Phase is crucial to student persistence, and a link to future success, educators have an interest in exploring ways to facilitate learning and development in this phase. Why certain students outperform others may provide knowledge that will help enhance the educational experience. Previous research in other fields has extensively, though separately, documented the association of academic performance with prior academic achievement, cognitive style, and learning style (Jansen & Bruinsma, 2005; Kolb & Kolb, 2005a; Minear, 1998; Riding & Cheema, 1991; Riding 1997; Riding & Agrell, 1997; Wilson, 1983; Yukhina, 2007). However, few studies address these variables in design education, and none address the three in a single study or within the context of VCD education. Moreover, Kvan and Yunyan (2005) make the general observation that, “for all [its] prominence, we still do not understand much that happens in design studio learning and research into learning process in the studio,” (p. 19).

Research Problem and Conceptual Framework

Research Problem

The research problem addressed in this thesis is: *How can knowledge of VCD students’ prior academic performance, cognitive style, and learning style help predict future success and inform instructional design for the Transitional Phase in VCD education?*

The hypothesis is: *Prior academic performance, cognitive style, and learning style are predictive of student performance during the Transitional Phase in VCD programs.*

Based on the review of research literature, the following research questions were developed to explore the research problem, they address three areas: performance, preferences, and application.

1. Performance:

   What is the relationship between VCD students’ prior academic performance, cognitive style, and learning style, and their performance in the Transitional Phase?

2. Preferences:

What cognitive style and learning style do VCD students prefer compared to other groups?

3. Application:

   How can the knowledge created in this study be used to improve instructional design for the Transitional Phase in VCD programs?

This study explores three personal characteristics, or individual differences, that may be associated with student achievement in the Transitional Phase of VCD programs. Research by others suggests that these characteristics may influence educational and professional success in various domains. If similar results were found for VCD students, it may be possible to pinpoint ways to improve curriculum and student performance during the Transitional Phase of VCD programs.

Conceptual Framework

Figure 2 provides a concise representation of the theoretical relationship among the study variables, and the potential interaction and influence of the independent (or predictor) variables (IVs) on the dependent (or criterion) variable (DV). In practice, the interaction of these variables is unique to each study participant, depending on his or her scores. For example, one student might demonstrate a high correlation between prior academic performance, a particular learning style, and scores on transitional phase projects, while a second student might show a little or no correlation among these same variables. These interactions are described in aggregate in “RESULTS,” p. 113.

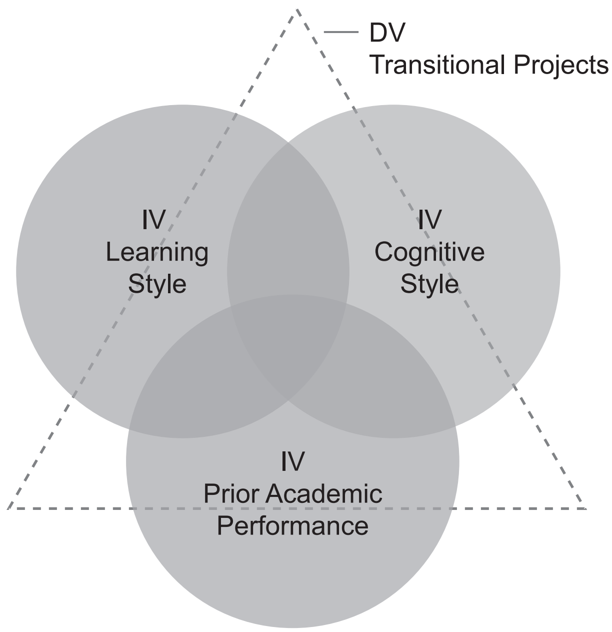

Figure 2. The theoretical influence of the independent variables on the dependent variable. IV = independent variable, DV = dependent variable.

Justification

Research Literature

The study of VCD education is relatively young and lacks the abundance of research literature found in related fields such as architecture, industrial design, and interior design. The literature search located numerous commentaries and perspectives on VCD education based on anecdote and experience, and studies that used interviews and other qualitative methods, but few empirical or quantitative studies, and none that employed the instruments and methodologies used in the present study. This gap in the research literature presented an opportunity to create new knowledge about the field of VCD education.

Admission, Instructional Design, Persistence, and Success

The chief practical objective of VCD programs is to graduate students accomplished in the educational goals of each program: aesthetic excellence; conceptual communication skills; critical thinking, reasoning, and research skills; and interpersonal skills for working with teams and clients (Heller, 2004, 2005; Kelly, 2001b; McCoy, 1997; Poggenpohl, 2004; Wilson, 2001). Accepting and sustaining students in these academic programs requires substantial investment of time and resources by students, faculty, and host institutions. Limited program resources dictate limited enrollment. Thus, it is in the interests of all parties that a program graduate a high percentage of students with the intended qualifications, and with promise for professional success.

With this imperative in mind, most VCD programs screen applicants at the time of their initial application, and subsequently after the first or second year, for continuance in the program. Kelly (2001b) noted “Students who exhibit a lack of interest in learning should be dropped from the program during the first year. This action should be taken without exception or regret, because these students seriously detract from the program for committed students” (p. 81).

Thus an interest of this study is the systematic examination of variables that the literature suggests may predict student performance and improve instructional design, screening procedures, student persistence, and graduation ratios within VCD programs.

Methodology

The conceptual basis, methodologies, choice of variables, psychometric instruments, and analyses used here were derived from a combination of related studies of academic performance, cognitive style, and learning style in undergraduate design education, and in general education.

The study’s participants were 37 transitional-phase students in ASU’s VCD program (third-year, first-semester, fall 2006). The participants voluntarily provided researchers access to their academic record data; their scores from Peterson’s (2005) revision of Riding’s (1991) Cognitive Styles Analysis (CSA); and their scores from Kolb and Kolb’s (2005a) Learning Style Inventory (LSI). These constituted the study’s IVs. The

DV was the participants combined scores on six design projects performed during the Transitional Phase semester.

The students' data were parsed and encoded according to the procedures prescribed for each variable, then were statistically analyzed with methods that included correlation, multiple linear regression, analysis of variance (ANOVA), *t* tests, and various follow-up tests.

Limitations

The author acknowledges and specifies the following limitations to the present study:

1. This is a pilot study. The literature search revealed no studies that used a similar combination of variables for research in VCD education. Pilot studies help establish procedures, refine research questions and methodologies, and cope with technical and analytic issues (Lenth, 2009). This study should be regarded as an incremental step towards structuring future studies.
2. This is not an experimental study. Although the data gathered are quantitative, this study is exploratory and descriptive, not experimental. The enquiry is about existing relationships among variables rather than controlled manipulation of variables.
3. This study used *purposive nonprobability sampling.* This is an inherently biased, but widely accepted, method for exploratory studies in the behavioral sciences. Data collection was limited to a single class in ASU's undergraduate VCD program. Although this furnished valuable insights to inform subsequent studies, investigators are cautioned not to apply interpretations beyond the sample (Tongco, 2007, p. 151).
4. The judges that evaluated the DV were limited to four faculty members of the VCD program at ASU. Professionals from outside the institution were

not included.

5. No statistical power analysis of the study was conducted. The author was aware that there was insufficient power due to the sampling method and sample size. The intent was to demonstrate the methodology. Power, sample size, and alternative analyses are addressed in the “DISCUSSION,” p.129.
6. The study focused on particular learning theories, psychometric instruments, and applications to instructional design relevant to the inquiry: (a) style-oriented theories, specifically Kolb’s (1984) Experiential Learning Theory (ELT), and (b) Riding and Cheema’s (1991) Cognitive Style Theory (CST), and their associated instruments; and (c) Collins, Brown, and Holum’s (1991) cognitive apprenticeship model.

Conclusion

This chapter introduced the foundations of this thesis. It specified the research problem, hypothesis, research questions, and justification for the study. It also summarized the conceptual framework and methodology, and finally the limitations of the research.

The following chapter, “REVIEW OF LITERATURE” surveys the literature that suggested the course and methodology of the study. It encompasses writings about the nature of design problem-solving; the history of VCD; VCD education; learning theory and instructional design; the personal characteristics of academic performance, cognitive style, learning style, and their relevance to education; and finally the findings and opportunities that the review revealed. Following this, the “METHODOLOGY” chapter describes the participants and how they were selected, and the study variables and how they were analyzed. Next, “RESULTS” details the data analysis. And finally the “DISCUSSION” considers the results in the context of the research questions and literature, and their implications for theory and instructional design.

2 REVIEW OF LITERATURE

This review is divided into six sections. The first section introduces design problem solving and the types of problems encountered in design and design education. The second section focuses on the history and of practice VCD; the third, on the history and of practice of VCD education. The fourth section reviews learning theory and instructional design relevant to the present study. This includes issues of psychometric testing and measurement, an introduction to the learning-style and cognitive-style theory and models used in this study, and the cognitive apprenticeship model of instructional design. The fifth section turns attention to the application of the foregoing material to the study variables, and the specifics of personal characteristics and performance in studies of education and design education. The final section sums up the findings and opportunities that surfaced as a result of the literature review.

Problem Solving in the Design Disciplines

This brief section presents an introduction to problem types, and problem solving strategies, which are referred to throughout the remainder of this document. These are provided to facilitate an understanding of design process and related learning theories, which are evaluated in subsequent sections.

Problem Types

Schraw, Dunkle, and Bendixen (1995) reported studies that found a close relationship between effective problem solving and domain-specific knowledge. However, they noted that problem solving ability is not fully explained by knowledge alone. Knowledge-based problem solving in one domain is not necessarily transferable to other domains, and problem structure plays a significant role in the way people pursue solutions. Accordingly, Kitchener (1983) proposed that problem structure could be classified in terms of increasing complexity: *well-defined problems*, *ill-defined problems*, *wicked problems*, and *super-wicked problems*.

Well-defined problems are those “for which there are absolutely correct and knowable solutions.” Well-defined problems are limited in two ways: (a) there is only one correct solution that can be determined with complete certainty, and (b) there is a guaranteed procedure available to reach that solution. In contrast, Ill-defined problems are those “for which there are conflicting assumptions, evidence, and opinion which may lead to different solutions,” (Kitchener, 1983, p. 223). Ill-defined problems may (a) have multiple solutions, or (b) no solution at all, nor (c) is there a guaranteed procedure to reach that solution.

Wicked problems share the attributes of ill-defined problems, with the additional characteristic that they are essentially a “one shot” opportunity in which each effort at a solution fundamentally modifies the problem definition and is irreversible. In addition, every wicked problem is (a) unique, (b) can be considered to be a symptom of another problem, and (c) holds the problem-solver liable for the consequences of his or her actions. Social policy planning is a typical example of a wicked problem (Rittel & Webber, 1973).

Super-wicked problems share the attributes of wicked problems, with the additional characteristics that (a) time is running out, (b) there is no central authority, and (c) those seeking to solve the problem are also causing it. Global climate change is a paradigmatic example of a super-wicked problem. In general this category of problems is not within the purview of VCD.

Problem Solving Approaches and Style

Some theorists identify distinctions among cognitive styles and learning styles when evaluating approaches to design problem-solving (Coffield, 2004a). Cross (1985) reviewed and evaluated various approaches to design problem-solving in this context and reasoned that, “[if] people have very different learning styles, then we would also expect them to have very different designing styles…Yet differences in cognitive styles are rarely, if ever, explicitly acknowledged in design theory, design methods or design education" (p. 158).

Based on his review, Cross distinguished between three approaches proposed by others: (a) serialistic versus holistic, (b) convergent versus divergent, and (c) focused versus cascading. He concluded that:

> These research results lend support to the notion that there are particularly appropriate, 'designerly' strategies for solving design problems. These strategies are justifiably different from those used in other fields, such as the sciences, and arise from the intrinsically ill structured nature of design problems. (p. 160)

Schön (1983, 1985) also observed that learning in the design studio centered on Ill-defined problems and a problem solving process he termed "reflection-in-action." In his view, traditional knowledge- and rule-based approaches (what he termed "technical-rationality") fail to fully account for how professionals actually solve ill-defined design problems. He maintained that ill-defined problems require a greater level of engagement, in which designers learn from the problem as they work through it, then incorporate that new knowledge back into the formula for the solution.

Schraw et al. (1995) concluded that individuals' epistemic beliefs had a bearing on how they solved ill-defined, but not well-defined, problems, and noted that their findings supported Kitchener's (1983) structural model. This is logical since people rely on their own judgments and experience when they lack a rule-based procedure. Echoing this finding, Demirbas and Demirkan (2003) observed that "In solving the design problem, the extent of the experience of the designer is more important than the facts and rules" (p. 439).

In VCD, as in the other design disciplines, students and practitioners typically deal with ill-defined problems, and to a lesser extent, wicked problems. To address the specific requirements of VCD problem solving, noted designer and author Phillip Meggs (1989) proposed the model shown in Figure 3. Although this model shares features of a serialistic strategy, it contains reflective "loops" that can accommodate other strategies.

It also echoes Schön’s (1983) reflection-in-action model, but specifically adapted to VCD, and without overt reference to cognitive processes or learning styles.

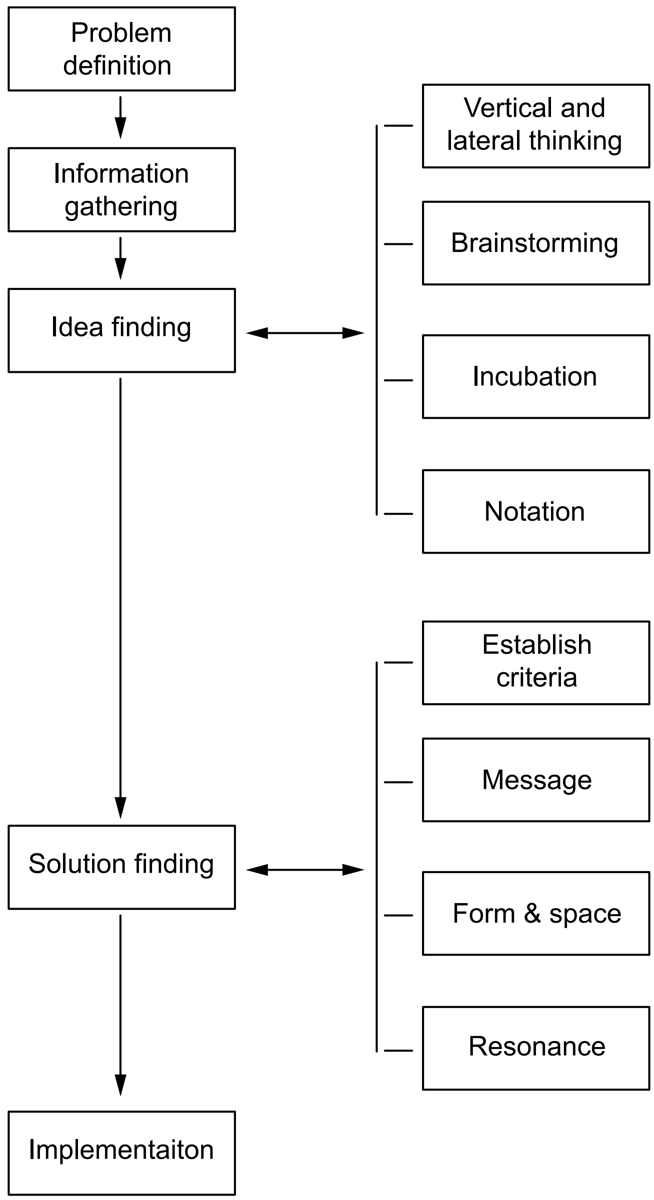

Figure 3. A diagrammatic adaptation of Meggs’s (1989) model of graphic design problem solving (figure author: J. Murdock, 2008).

Visual Communication Design

This subsection briefly describes the evolution and contemporary state of VCD and of its relationship with the Arts, and other design disciplines. Keys to understanding the field are in recognizing its eclecticism and the breadth of proficiencies that it requires.

Overview and History of Visual Communication Design

"Graphic design," has operated under many identities throughout its brief history. Even finding consensus on a definition of the discipline is elusive. McCoy (2005) observed, "there is little agreement on the proper nomenclature… Graphic designers themselves are not the only ones having difficulty defining their role. Graphic design's professional status is by no means universally accepted" (p. 1). Butler (1995) noted, "The confusion and difference of opinion regarding the definition of graphic design is not surprising. The varying background and training of graphic designers and the wide range of problems they address combine to form a discipline around which definition consensus is difficult, if not impossible," (p. 2).

Swanson (1994) added further depth, identifying design as a "synthetic" discipline that:

> …does not have a subject matter of its own—it exists in practice only in relation to the requirements of given projects. The path of progress for the field is not defined by the next great unsolved design problem. Design is "integrative" in that, by its lack of specific subject matter, it has the potential to connect many disciplines. (p. 54)

Perhaps Meggs (1989) offered the clearest perspective:

> Graphic design is a hybrid discipline. Diverse elements, including signs, symbols, words, and pictures, are collected and assembled into a total message. The dual nature of these graphic elements as both communicative sign and visual form provides endless potential for invention and combination. Although the visual arts share properties… graphic space has a special character born from its communicative function. Perhaps the most important thing that graphic design does is give communications resonance, a richness of tone… [that] intensifies the message and enriches the audience's experience. Resonance helps the designer realize clear public goals: to instruct, to delight, and to motivate. (p. 11)

In order to understand "graphic design" (or, using the contemporary term, "visual communication design," or VCD), it is useful to review the historical context from which it arose. Although VCD is a phenomenon of the 20th century, and largely of the latter half of that century, mark-making by hominids has been established as far back as 200,000 years, and the use of visual symbolism is evident in cave paintings dating as far back as

35,000 B.C. (Meggs, 1992, p. 4).

Modern VCD has its roots in European type cutting and book printing, whose primary purpose was the visual presentation of verbal language through typography. Typography, a highly sophisticated system of symbolic communication, was intended as a neutral and transparent vehicle for this communication. This contrasted with the symbolic visual imagery common in painting and “High” art. Because of its functional intent, bookmaking was regarded as a craft rather than an “Art.” It was not until the industrial revolution of the nineteenth century, and the accompanying revolution in printing technologies, that the verbal and linguistic content of the written word began to be widely, and effectively, paired with the experiential and emotional content of imagery. These advances allowed designers to transcend the strictures imposed by the craft of bookmaking and the limited techniques available for printing images.

Early twentieth century artistic movements such as Futurism, Dada, Constructivism, and De Stijl forwarded this trend by rejecting traditional divisions between fine arts, applied arts, and crafts—exemplified, for example, by the Futurists’ experimental poetry. Modernist designers like those of the Bauhaus similarly took the view that art, craft, and design were properly embodied within a unified philosophy. These conceptual and technological currents formed the foundation of a new synthetic discipline that ultimately became VCD (Butler, 1995; Davis, 1998; McCoy, 2005; Wilson, 2001).

In time, American VCD was heavily influenced by European Modernism and inspired by the Bauhaus, and subsequently, the Swiss School. Systematic, rational, and functional, this approach emphasized methodology over the efforts of the lone genius popularized by the “big idea” philosophy of the New York School during the 1950s and 60s. The Swiss influence had a heavily professionalizing effect and was eventually adopted as the gold standard for American corporate design, and much of VCD education.

Theoretical ideas from outside the field, such as semiotics, also began to inform and codify graphic design theory during the 1960s. These, along with the publication of Meggs's *A History of Graphic Design* in 1983, and the emergence of graduate programs in graphic design further concretized the professional status of the discipline. As Massimo Vignelli stated, theory as well as history and criticism are the essential trinity that distinguish a profession from a craft or trade (McCoy, 1990).

In recent years, movements such as postmodernism, deconstruction, and poststructuralism have challenged the unemotional and methodical predictability of the Swiss approach. However, it remains to be seen whether these trends will prove themselves practical and lasting in the marketplace, or relegated to the status of fad and experiment. Certainly, the rise of interactive electronic media calls for alternatives that revise the hierarchical structure of traditional print design in favor of a more conversational model (Search, 2003).

Contemporary State of Visual Communication Design

Echoing the advances in printing technology that transformed VCD during the late nineteenth century, the ongoing advances in digital technology, which began in the late twentieth century, continue to reshape visual communications. The proliferation of information delivery systems, and the attendant cultural dependence on these systems, has created unprecedented demand for visual communications.

Ironically, the computer, first lauded as technological liberator, later revealed itself as culprit, by adding entirely new layers of competency and expertise to VCD's basic job description. Prior to the advent of the computer, designers primarily focused on design, and secondarily, managing outside resources; studios effectively handled multiple jobs by subcontracting tasks such as color separation, illustration, and typesetting, to specialists with the necessary expertise and equipment (Butler, 1995; Davis, 1998; McCoy, 2005). Dazzled by the computer, many designers failed to recognize that although the computer enabled them to perform tasks that they previously relegated to others, preoccupation with personal use of the computer could divert their focus from their area of professional expertise (Kelly, 2001c). In addition, this new technology enormously expanded the number of areas that required good visual design, including the internet, games, cell phones, DVDs, and other forms interactive electronic media. The pace of the expansion continues to accelerate.

Designers' gradual recognition of the growth and complexity of VCD spawned a diversity of specialists trained to address both old and new demands with the new digital technology. Yet, many organizations that employ visual designers have not recognized these dynamic changes. Job postings frequently reflect the expectation that applicants should demonstrate technical expertise in every facet of the field, without recognizing that these requirements essentially describe several different and separate jobs. Today's visual designers are employed as strategists, aestheticians, production managers, consultants, and for whatever related opportunities emerge each year in response to the demand for highly-specialized sub-disciplines (Wilson, 2001).

The overarching consideration of the forgoing for this thesis is the recognition that the field is eclectic and ever-expanding, and that success is based in ill-defined problem-solving skills and adaptability, paired with an experiential library of design and technical knowledge.

Visual Communication Design Education

The following subsection presents a brief history of VCD education as it relates to the structure of contemporary VCD programs in the United States, and specifically to the program at ASU. This review is not exhaustive, but rather is intended to establish similarities in the structure of contemporary programs with their antecedents, and commonalities that support the logic of this study.

History And Consequences For Contemporary Programs

The industrial revolution bore an array of consequences: the concentration of populations, an abundance of consistently manufactured consumer goods, a strong middle class with the wherewithal to consume, and the growth of mass markets. The field of VCD emerged from the necessity to communicate with consumers in these mass markets through advertising, magazines, and printing (Taylor, 1971).

However, the rapid change brought on by the industrial revolution, and the attendant low quality of machine-produced goods unsettled some critics, notably John Ruskin, William Morris, and other proponents of the Arts and Crafts movement. These scholars and practitioners foresaw an unconscious decline in the principles of aesthetic that were the paragon of the craft-guild tradition. They called for a rejection of “the machine,” and a return to hand craft. “Ruskin saw industrialization as a danger to both the consumer and the producer. The consumer risked being aesthetically tainted by the supply of low-quality and tasteless mass-produced articles. The producer risked being robbed by machine production of the possibility of contented self-realization,” (Wick, 2000, p. 20).

Other practitioners and professionals responded by organizing around a philosophy of uniting the ideals and aesthetic of handcraft with the realities of machine technology. An early example of such an association of artists, architects, industrialists, and merchants was the *Deutscher Werkbund* program, founded by Hermann Muthesius, Friedrich Naumann, Karl Schmidt, Peter Behrens, and others circa 1906. The *Werkbund* was a kind of society, initially comprised of 12 architects and 12 industrial firms, that sought to reconcile the apparent conflicts between art, handicrafts, industry, and trade. Although the *Werkbund* continued into the 1920s, the effort foundered with the advent of World War I, and with philosophic differences among its principals. However, its ideological gravity continues to influence discourse on art, technology, and design education (Gamard, 2004).

Architect Walter Gropius joined the society in 1911, but by 1918, transformed by the war, Gropius declared the Werkbund “dead.” The following year Gropius petitioned the German government to allow him to combine the *Academy of Art,* the *School of Architecture,* and van de Velde’s (then closed) *School of Arts and Crafts* into the *Bauhaus*—an institution that would unify the various disciplines and “create a new guild of craftsmen without the class-distinctions that raise an arrogant barrier between craftsman and artist!” (Gropius, cited by Wick, 2000, p. 31).

The foundation course in the Bauhaus program, required of all students, was developed by Johannes Itten and lasted two terms. It introduced students of art, architecture, graphic design, interior design, industrial design, and typography to abstract problems and universal principles common to all the disciplines in advance of the introduction of programmatic, applied design problems in subsequent terms. The instructors and specifics of the program evolved over the years, but this curricular model remained largely intact (McCoy, 2005; Wilson, 2001; Wingler, 1969). When the Bauahus closed in 1933, many of the principal educators immigrated to America, established similar programs, and flourished. The *Chicago Institute*, founded by Moholy-Nagy, was soon renamed the *School of Design* and continued to evolve. By 1959, “the curriculum for graphic design began to look very similar to the curriculum we have today” (Wilson, 2001, p. 28).

In parallel, a number of Swiss schools began developing a uniform approach to graphic design education after in the years after World War II. The *Zurich School of Arts and Crafts,* and the *Basel School of Design* exemplify this movement. The curriculum established at the Zurich school consisted of three blocks of study and echoed the structure of the Bauhaus program with the first year devoted to formal studies, typography, and photography. The second and third years resembled an apprenticeship with students applying the formal knowledge of the first year to work commissioned to the school. Finally, the forth year consisted of two semester-long projects that put all previous learning and experience into practice (Müller-Brockmann, 1961).

Like the Bauhaus, the Swiss pedagogical model also migrated to the United States during the 1960s and 1970s to institutions that included the Philadelphia College of Art, University of Cincinnati, and Yale University as the Swiss schools' graduates immigrated to the US. The instructional model provided a systematic and teachable curriculum unlike the difficult to teach "Big Idea" school of thought that prevailed on Madison Avenue and other New York studios of the 1960s and 1970s. The three-part program exemplified by the Bauhaus and Swiss curriculum—a sequence of core, transitional, and professional courses—forms the basis of most contemporary four-year visual communication design programs (Kelly, 2001b; McCoy, 2005; Wilson, 2001).

In 2001 Wilson conducted a survey of 50 VCD faculty members from various institutions and 80 practicing VC designers, to investigate the current state of VCD education. The responses led him to conclude:

> A majority of graphic design programs offer the same curriculum at the lower levels. Course content can vary greatly, but most require a foundation/core/preliminary sequence of classes similar to the Bauahus model. The classes are usually broken into studios consisting of 2-D and 3-D design, drawing, color theory, and design principles.
>
> And:
>
> For the most part, design programs today are sequential in the upper division courses, with assignments building upon earlier projects. The scope and complexity of the projects in the third and fourth year are meant to give students the opportunity to tackle the problems they will find in practice. (p. 66-67)

McCoy (1998) echoed these observations: "Programs that already offer highly linear design curricula are more concerned with developing a strong and comprehensive understanding of basic principles during foundation courses, gradually building up to experimentation and conceptualization" (p. 12).

Issues Facing Contemporary VCD Education

As detailed above, rapid advances in digital technology and information delivery during the last 30 years resulted in unprecedented demand for specializations within the profession. These advances outstripped the capacity of academic institutions to supply specific training in a range of new areas. Four-year academic programs are hard-pressed to rapidly develop curricula that address the diversity of sub-disciplines, and simultaneously provide graduates with legitimate qualifications (Butler, 1995; Davis, 1998; McCoy, 1998). These competing considerations intensify the difficulty educators face in achieving the necessary balance between theoretical and practical skills.

Swanson (1994) observed “A primary task of design education is to find the balance between skills training and a general understanding that will benefit students, the field of graphic design, and working professionals” (p. 61). Simply having a substantial understanding of formal values and designer-thinking is not a sufficient qualification for employment, nor does an impressive array of technical skills qualify an individual as a designer. To adequately balance these goals Heller (2004), and McCoy (1998), proposed extending VCD programs to five and seven years respectively.

However, extending a program’s duration presents a cost/benefit dilemma: limited means compel most students to finish their degree as soon as possible and hit the streets with “entry-level” skills. Yet without a sufficient foundation, students wind up short on those skills; today’s graduates are expected to command a diverse array of competencies in software, delivery systems, production, conceptualization, and problem solving. This is further aggravated by the fact that academic programs in general tend to lag behind advances in technology in their offerings.

Critics such as Swanson have argued that because programs are out of touch with advancing technology, they offer yesterday’s design education: “Design teachers should teach basic principles of form and communication, but are, by teaching what they were taught, teaching the graphic designers of the twenty-first century how to be mid-twentieth century graphic designers" (1994, p. 58). Butler (1995, citing Owen, 1991) elaborates on this critique, maintaining that the selection of design faculty is:

> an incestuous process which 'operates to maintain the status quo and retard evolution of design programs' ([Owen], p. 31). Owen is also critical of the design student. He argues that he or she often chooses the design program because a broad range of interdisciplinary educational requirements, (e.g., mathematics, science, and language arts), is not part of the curriculum. This combination of instructors and students perpetuates an ineffective educational process. Instructors often lack a sufficient degree of professionalism; graduate students are said to have similar shortcomings. Some of these students return to academia as instructors and provide instruction similar to that which they themselves had received. According to Owen, the cycle remains unbroken. (p. 1)

A somewhat dysfunctional response to these pressures is evinced in the proliferation of technical and trade-oriented vocational programs offering nuts-and-bolts technical courses with little primary-stage education in design fundamentals, (Irwin, 2004). Of course, traditionalist educators object since this tends to produce technicians, not designers, but the practical alternatives are limited.

The balance is precarious. Kelly (2001d) observed: "Students must have technical information and abilities, knowledge of professional practices and contact with working designers who are good role models." However, "In school the goal is learning; professionalism is achieved on the job. It is important to aim the program at the highest levels of the profession rather than directing it toward employment opportunities within the immediate community" (p. 91).

Kelly also emphasized the importance of establishing a strong base of perceptual skills before transitioning students to conceptual, or professional exercises. He warned that teachers often try to accomplish too many objectives within a single problem, which leads to confusion and frustration with materials and mechanics, and lack of clearly defined goals. Similarly, strict deadlines should be avoided in early semesters since students tend to make the deadline the primary objective rather than learning the design process.

Some educators (e.g. McCoy, 2003) disagree with maintaining a stringent division between teaching formal principles and applied communication, and question whether these should ever be taught separately. However in her 2003 treatise, McCoy acknowledged that her specific criticism was based on limitations of time in a particular course.

The VCD Program at Arizona State University

Professor Kelly established ASU's present program in 1983. He was heavily influenced by the structure of the program at the Basel School of Design and the ideas of its Director, Armin Hoffman, with whom he had close ties. Furthermore, a number of Basel graduates have filled faculty positions in ASU's VCD program over the years. This structure and tradition is consistent with the models of the Bauhaus and Swiss schools discussed in above. This structure provided an ideal opportunity for exploration of the research questions identified on pages 3 and 4.

At the time of this study (fall semester, 2006) ASU's program was a two-tier structure consisting of two years of theoretical foundation courses followed by two years of upper level courses composed of transitional, then pre-professional applied projects (see Figure 1, p. 2). At the end of the second year students were required to apply for admission to the upper level in order to continue. A faculty committee reviewed each applicant's:

- previous VCD studio work,
- overall college GPA,
- VCD studio course GPA, and
- written statement of intent.

Previously, under Kelly's direction, the department only used an initial review for admission to the program that consisted of:

- a visual test with sections on line drawing, concept, color, visual and verbal directions, and design orientation;

- GPA; and
- five examples of the students' work (optional).

Kelly (2001a) noted "This was a very objective process for selecting students, but we did not seem to have any better students than if we'd used other procedures. Perhaps a lottery is next" (p. 50). However, Kelly was exceptionally adept at encouraging first-year non performers to seek alternative academic pursuits.

Conclusion

This subsection reviewed the history and contemporary state of VCD education, contemporary challenges facing the field, and a few specifics about ASU's program. Further details about the application of a formal system of instructional design to VCD education appear in "Cognitive Apprenticeship and VCD education," p. 87. Details of the Transitional Phase at ASU appear in "Dependent variable," p. 106.

Learning Theory and Instructional Design

Introduction and Definitions

This subsection reviews literature on learning theory and instructional design relevant to the present study. It begins with an overview of concepts of learning theory and eclectic approaches to instructional design, then shifts to focus on the two models specific to the research questions and area of study: (a) learning-style based theories (Kolb & Kolb, 2005a; Riding & Cheema, 1991), and (b) cognitive apprenticeship (Collins, Brown & Holum 1991; cf. Collins, Brown & Newman, 1989).

Learning theories are descriptive models that attempt to make the learning process understandable and practical for teaching and instructional design. There are many theories, which may overlap, or contain elements that fit into more than one tradition. They may be broad, or address specific objectives. They may also include contributions from other areas of psychological research, such as motivation theory, that are not strictly learning theories, but have implications for learning and instruction (Driscoll, 1994; Mergel, 1998). Hill (1971) identified two goals of learning theory as: (a) providing a vocabulary and conceptual framework for interpreting observations about learning, and (b) suggesting avenues to solve practical problems. Many learning theories are virtually indistinguishable from, and overlap with theories of instructional design.

Instructional design is a program for teaching and learning. It usually involves (a) determining the current state and needs of the learner, (b) defining the goals of instruction, (c) creating an *intervention* to meet those goals, and (d) evaluating the consequences (Driscoll, 1994, Schneider, 1994). Please turn to “GLOSSARY OF TERMS”, p. xvii, for other definitions of terms used in this section.

A basic understanding of commonalities among learning theories is provided by Mergel’s (1998) taxonomy of the three major traditions:

- *Behaviorism*: Based on observable changes in behavior. Behaviorism focuses on a new behavioral pattern being repeated until it becomes automatic.
- *Cognitivism*: Based on the thought processes behind the behavior. Changes in behavior are observed and used as indicators as to what is happening inside the learner’s mind.
- *Constructivism*: Based on the premise that people construct their own perspective of the world through individual experiences and schema. Constructivism focuses on self-directed learning and preparing the learner to problem-solve in ambiguous situations.

The following theoretical models contain elements of these traditions, and represent different perspectives on how they can be used to structure coherent systems with practical applications.

Eclectic Approaches

While learning theories attempt to explain underlying mechanisms and possibilities for teaching and learning, the value of instructional design is measured in how well it translates to tangible results. Instructional design is pragmatic, and may not fit conveniently within the prescriptions of a single theory. Teachers have to figure out what works and judge how to make the best use of the strengths and weaknesses of theories for specific goals.

Ertmer and Newby (1993), took the position that the different levels of sophistication and knowledge among learners call for different instructional methods drawn from the various traditions. They proposed that the major traditions in fact represent a continuum of instructional strategies as depicted in Figure 4. The strategies promoted by different learning theories overlap and are concentrated at different points depending on the focus of the particular theory, the level of cognition required, and the goals of the learning tasks.

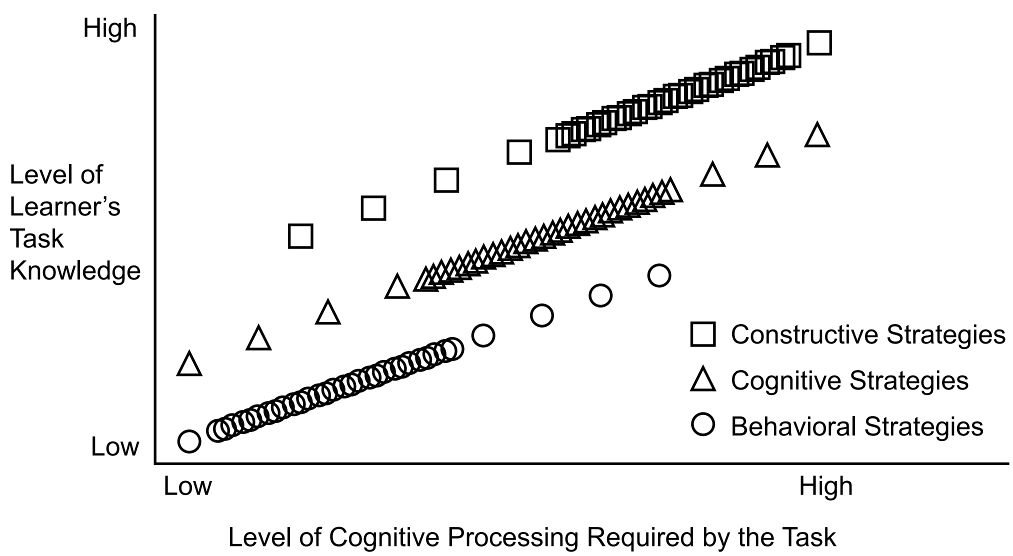

Figure 4. Comparison of instructional strategies of the behavioral, cognitive, and constructivist viewpoints based on learner's level of task knowledge and level of cognitive processing required. Adapted from "Behaviorism, cognitivism, constructivism: Comparing critical features from an instructional design perspective," by P. A. Ertmer and T. J. Newby, 1993, *Performance Improvement Quarterly*, *6*(4), p. 69. Copyright 1993 by John Wiley and Sons. Reprinted with permission.

In a similar vein, McCown, Driscoll, and Roop (1996) proposed a "reflective construction" model for incorporating various theoretical principles into specific curricula. Their model consists of a cycle of construction, reflection, and revision for addressing particular goals (Figure 5). This idea owes much to Shön's (1983) popular "reflection-in-action" paradigm, and also bears a distinct similarity to Kolb's (1984) ELT model, discussed in "Learning style," p. 49.

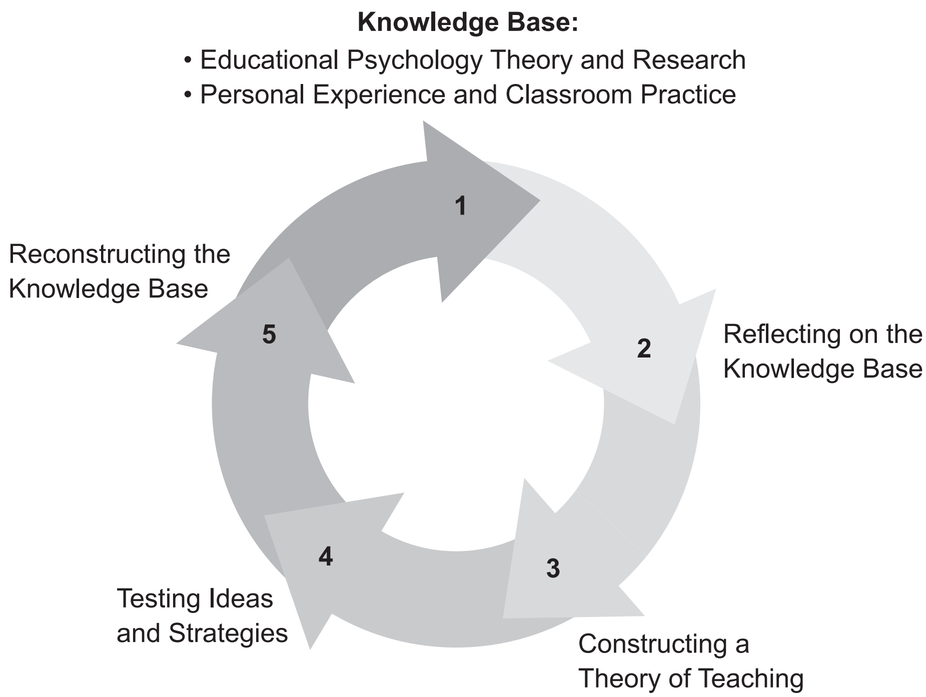

Figure 5. Continuous process of reflective construction of instructional design. Adapted from *Educational psychology: A learning-centered approach to classroom practice,* by R. R. McCown, M. P. Driscoll, and P. G. Roop, 1996, Boston: Allyn and Bacon. Copyright 1996 by Allyn and Bacon. Reprinted with permission.

Finally, Driscoll (1994), in an elaboration of McCown et al.'s model, suggested that educators use an eclectic approach to develop a "personal" theory of learning and instructional design, "with the expectation that it should serve as an improved guide to [their] own instructional practices" (p. 380). She pointed out that most educators who have studied learning theory and instructional design employ the same process of theory building used by the prominent learning theorists. Figure 6 depicts her comprehensive model. It seems particularly practical for educators tailoring instruction to specific goals, and for integrating personal experience with formal theory.

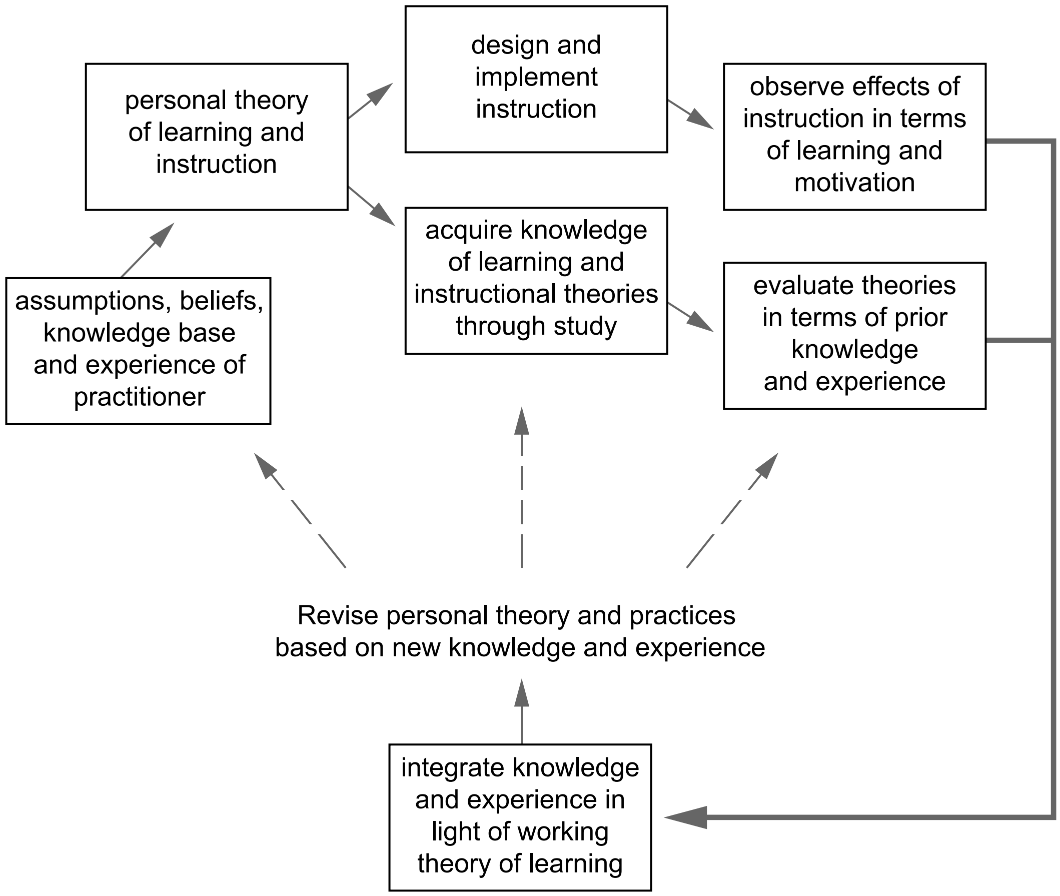

Figure 6. Building a personal theory of learning and instruction. Adapted from *Psychology of learning for instruction,* by M. P. Driscoll, 1994, Needham Heights, MA: Allyn & Bacon, p. 380. Copyright 1994 by Allyn and Bacon. Reprinted with permission.

Learning-Style Based Theory and Models.[1]

Two style-based theoretical models serve as foundations for this study's independent variables: Riding and Cheema's (1991) Cognitive Style Theory (CST) and model, and Kolb's (1984) Experiential Learning Theory (ELT) and model. The purpose of this subsection is to introduce the main features, practical implications, and issues shared by these models in advance of their detailed review in the following subsections.

Riding and Cheema's and Kolb's models are complex, incorporate elements

[1] The term "learning style" frequently is used generically to refer to both "learning style" and "cognitive style." We adopt this usage for the sake of economy, and will note when we are specifically referring to either one or the other.

of the major theoretical traditions, and may be categorized in different ways. Kolb maintains that ELT is a constructivist theory, although it is clearly and firmly grounded in cognitivism. Riding's model perhaps has deeper cognitivist roots but also embraces elements of constructivism.

Both share a similar bipolar, orthogonal structure, meaning that each consists of two axes that define distinct uncorrelated aspects of style preferences. This structure yields two continuous scale variables on the main axes (A-B, C-D) and four *bivariate* categorical variables resulting from the combined scores on the two main axes (*a-c, a-d, b-d, b-c*).

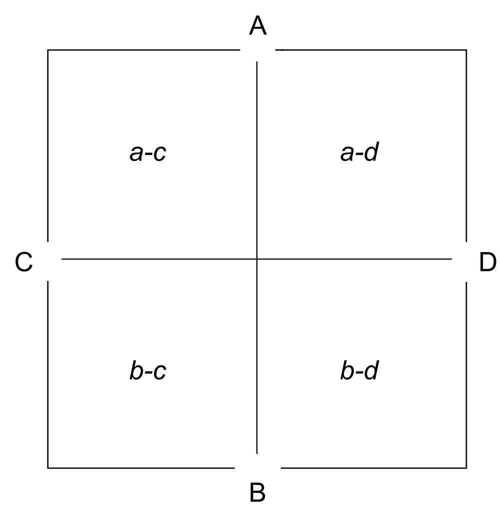

Figure 7. A generic representation of the bipolar style models used in the present study.

Each of the models has its own psychometric "test," or *instrument* designed to measure peoples' style preferences. These instruments yield scores on the main dimensions and the (bivariate) categories, as illustrated in Figure 7.

Although Riding and Cheema's, and Kolb's models share a common structure, they differ in their construct of styles. Cognitive styles are regarded as inbuilt properties of peoples' cognitive system, related to ability, and do not change much over time. Learning styles, on the other hand, are more adaptable, situational, and susceptible to change over time.

Psychometrics, testing, and measurement. In order to transform learning theory into practical instructional design developers need a way to test theoretical concepts and outcomes empirically. *Psychometrics* is the study of the theory, principles, and technique of educational and psychological assessment. Concepts such as knowledge, abilities, attitudes, and personality traits are intangible (or *fuzzy*), and cannot be measured directly—they must given *operational* definitions. This means defining them in a way that allows them to be measured in terms of empirical observations. Psychometrics is primarily concerned with (a) operationalizing and *validating* techniques for measurement through instruments, and (b) developing and refining theoretical approaches to operational measurement (McNiell, 2011).

Definitions. Some of the key concepts of psychometrics used in this subsection are:

- *construct*: any complex psychological concept. Examples would be: motivation, anger, personality, intelligence, love, fear, etc. Constructs may be constituents of theories, models, or conceptual frameworks. Constructs must be represented the form of an empirically testable item (i.e. *operationalized*), in order to be measured;
- *instrument*, or *psychometric instrument*: questionnaires, tests, and other empirical means of assessment. Instruments are known by various names: “inventory,” “assessment,” “analysis,” “questionnaire,” etc. They yield some type of summary data, usually quantitative.
- *Ipsative*: an ordinal (non-quantitative) measure. A respondent is asked to indicate his or her order of preference from among two or more options (sometimes called a “forced-choice” scale). An ipsative measure does not report the degree of difference between choices, only their rank order of preference. Ipsative measures are distinguished from *normative* measures,

which allow independent and non-exclusive choices of level of preference (e.g. asking how much one agrees with statements on a scale of 1 to 5).

- *measure*: in psychometric testing a "measure" may be synonymous with "instrument," or also refer to a particular method or test item used in an instrument;
- *normative sample*: a sample sufficiently large that its statistical characteristics are deemed to represent population *parameters* (also known as a *standardization sample*);
- *operationalize*: creating empirical measures from constructs
- *reliability*: the extent to which an instrument or study is consistent in its measurements. An instrument that is valid is also reliable. But, a reliable instrument may not be valid (see below). That is, it may accurately and consistently measure something that is irrelevant to the constructs. There are many specific types of reliability (see GLOSSARY OF TERMS, p. xvii);
- *split point* (or *cut point*): the numeric value (usually the median) at which a continuous scale variable is divided to create categories, or categorical variables. In the present study these pertain to variables in cognitive style and learning style models;
- *standardization sample*, see "normative sample;"
- *validity*: the degree to which an instrument or study accurately reflects or assesses the constructs it is attempting to measure. Validity and *reliability* are two epistemological issues addressed by psychometrics. There are many specific types of validity (see GLOSSARY OF TERMS, p. xvii) (alleydog.com, 2011; Coladarci, Cobb, Minium, & Clarke, 2004).

Testing and measurement issues in learning style research and instructional design. This subsection summarizes salient issues relevant to the present study and owes much to Coffield et al.'s recommendations (2004a, p. 133-146). This provides a foundation and understanding for the detailed review of research findings that appear later in this paper.

First, many authors appear to assume that the field of cognitive and learning style research is unified and monolithic, and use terms, labels, and vocabulary interchangeably, as though there were consistent and agreed upon definitions. In fact, the field is plagued with vested interests, fraught with unacknowledged inconsistencies, and needlessly complicated:

> The sheer number of dichotomies betokens a serious failure of accumulated theoretical coherence and an absence of well-grounded findings, tested through replication. Or to put the point differently: there is some overlap among the concepts used, but no direct or easy comparability between approaches; there is no agreed 'core' technical vocabulary. The outcome—the constant generation of new approaches, each with its own language—is both bewildering and off-putting to practitioners and to other academics who do not specialise [sic] in this field. (Coffield et al., 2004a, p. 136)

In many cases this ruins the translation of research findings into instructional design because the vocabulary is too vague to support universal agreement and understanding. Also, many of the most popular and widely used instruments "have such serious weaknesses (e.g. low reliability, poor validity and negligible impact on pedagogy) that [Coffield et al.] recommend that their use in research and in practice should be discontinued" (p. 138).

Second, researchers face the paradox that the oldest instruments are the most researched and publicized, although they may not be the most promising or refined. Researchers seeking literature relevant to their specific area of study, and for justification of specific hypotheses typically gravitate to instruments with the widest history of research because those may be the only resources that touch on their specific interest.

A third obstacle to translating research into instructional design comes from the practice of educational assessment itself. Operationalizing constructs necessarily requires limiting their underlying concepts. This is economical, but it can lead to misinterpretations of results and fundamental goals—such as education. Frequently the focus of educational programs becomes quantifiable assessment, rather than qualitative learning, under the assumption that the former represents the latter. Moreover, staff in schools, and collegiate education teach and assess curricula in ways that encourage *surface* or *strategic* rather than *deep* learning. For example, in a study of medical and education students, Desmedt, Valcke, Carrette, and Derese (2003, cited by Coffiled, et al., 2004a, p. 141) concluded that the structure of curriculum and assessment encouraged students to be primarily interested in assessment, not learning. Similarly, Hattie (1999) observed:

> Perhaps it is no surprise to note that students who survive university undergraduate degrees are those with impeccable surface and not deep strategies, those who learn to be flexible to the instructors assessment demands which so often value information and not understanding, and that the students with the more deep, critical, and passionate learning strategies have the highest probability of not completing our degrees. (p. 10)

Reynolds (1997) extended this criticism of misplaced focus to learning-style research, which he excoriated because “the very concept of learning style obscures the social bases of difference expressed in the way people approach learning…labelling is not a disinterested process, even though social differences are made to seem reducible to psychometric technicalities” (p. 122, 127; as cited by Coffiled, et al., 2004a, p. 141). In other words, focusing on style labels essentially disregards the concepts of learning, social class, race, and gender as relevant considerations,

Finally, Coffield et al. call attention to the disconnect and lack of coherence caused by academic territorialism, particularly between sociology and psychology, whose practitioners “pass each other by in silence, for all the world like two sets of engineers drilling two parallel tunnels towards the same objective in total ignorance of each other” (p. 143).

Psychometric issues. All psychometric instruments inherit peculiarities from (a) the structure of their theoretical constructs, and (b) the mechanics of operationalizing those constructs. Authors of effective instruments find clever ways to take advantage of these inevitable challenges, but there are abundant pitfalls. The instruments used in the present study are no exception. Awareness of these pitfalls and potential weakness are essential for properly understanding and interpreting research in cognitive and learning styles.

First, too much is expected of relatively simple self-report inventories. Self-report inventories ask respondents to express their impressions or opinions, rather than measuring actual behavior. This introduces a layer of mental mediation between the construct and the measurement. For instance, a person could be completely unaware of how they behave in a situation, but provide an answer that is “appropriate,” or other unconnected reason. (A notable exception is Riding / Peterson’s CSA, used in the present study, which measures reaction time, rather than opinion, as the criterion).

Second, respondents may be overly constrained by particular formats. Many questionnaires are forced-choice (ipsative) structures that compel an exclusive order on choices—i.e. choosing an item as “1” means that any other choice must be “2”, “3”, “4”, etc. This is advantageous since it reduces data and simplifies analyses, but critics have argued that it may also oversimplify constructs, and thus threaten construct validity (Coffield, 2004a). However, Kolb and Kolb (2005a) contended that this is the way people actually make choices in life—doing one thing means you cannot do another. Third, the above is compounded by questionnaire items that are vague and which respondents may interpret differently: “People often find me insensitive to their feelings,” and “I like to feel what I learn inside of me” (from Honey & Mumford, n.d.; Dunn, Dunn & Price, n.d.; cited by Coffield et al., 2004a, pp. 141, and 128 respectively).

Finally, while statistical and scoring procedures continue to become increasingly sophisticated, questionnaire items tend to lag behind with simplicity and vagueness. This is partially due to the inherent pressure on developers to resist revising test items because, if even a few items are reworded, it essentially creates a new instrument. Hence, the accumulated evidence for the instrument's validity and reliability becomes irrelevant.

The quantitative / qualitative debate. Psychometrics is regarded as a subfield of quantitative psychology, and as such, is preoccupied with measurement and assigning numbers to phenomena (American Psychological Association, 2011). However, one of the challenges researchers face using quantitative methodologies is that a small number of cases, and more than a few variables usually pose problems for statistical analyses. On the other hand, qualitative methods usually involve fewer cases and many variables. Quantitative strategies seek to produce valid results by reducing interpersonal contact between researchers and subjects; qualitative approaches view interpersonal involvement as a necessary and beneficial tool for understanding.

So how do researchers use quantitative methods to study small, specific groups that are the research interest? Ultimately researchers have to make careful decisions about balancing trade-offs between validity, resources, peripheral influences, and stress on participants. Obviously, considering and designing a research strategy primarily depends on the nature of the research problem and research questions, not a stock formula or particular method of analysis (Neuman, 2005).

Increasingly researchers combine quantitative and qualitative methods since the two can support each other and be integrated in helpful ways. First, Qualitative methods can be used to develop quantitative research tools. Day-to-day interactions with students, peers, and faculty spark ideas for instructional design and classroom innovations that can be tested in quantitative ways through surveys and other instruments, and also ideas for refining and operationalizing constructs. Second, qualitative methods can be used to resolve conflicts found in quantitative data. For example, a statistical correlation, or effect, that seems illogical may be the result of the influence of a hidden variable. A small-scale qualitative investigation may provide clues to those influences. Third, by combining approaches researchers may be able to triangulate findings and gain a more complete understanding of their area of study (Babbie, 2007; Neuman, 2005). We return to these thoughts in the “DISCUSSION,” p. 129.

The “matching hypothesis.” Many authors have argued that more successful learning is achieved when the style of teachers, presentation, and instruction, is matched to the style of students (Coffield, et al., 2004a; Pask, 1988; Rayner, 2001; Riding, 1998, 2002). Logically, instructional design that is limited to a particular style would be expected to disadvantage students having a different style.

Hinting at this, Riding and Rayner (1998) found cognitive Style Types unequally represented in a range of occupations; Kolb and Kolb (2005a) also found that students' learning styles differed by academic field. In addition, some research suggests that American universities operate almost exclusively towards an analytic model that disadvantages students with a relational or holistic orientation: teachers tend to be analytic learners, and the longer people stay in the educational system, the more analytic they become (Coffield et al, 2004a; Cohen, 1969; Coverdale, 2003). Riding and Agrell (1997), argued that Analytic-Verbal students are “most naturally suited to academic work,” because that is the principal orientation of teachers and programs (p. 321). Furthermore, Kolb and Kolb (2005a) found a linear relationship between “abstractness” in learning style and the years people spent in education—from elementary through graduate school. These findings and others have raised the concern that, regardless of interest and motivation, some students may find themselves at odds with the cognitive or learning style of particular academic programs.

The matching hypothesis has enjoyed enormous popularity in Education. But despite its superficial allure, it invokes a number of complexities. First, the definitions offered in the literature seem too vague to be practicable:

> (a) tailoring teaching to ‘‘the way in which each learner begins to concentrate on, process, absorb, and retain new and difficult information’’ (Dunn & Dunn’s framework; International Learning Styles Network, 2008), (b) the learner’s preferred modes of perception and processing (Kolb’s, 1984, 1985, framework), or (c) ‘‘the fit between [people’s] learning style and the kind of learning experience they face’’ (Hay Group, n.d., p. 11, cited by Pashler, McDaniel, Rohrer, & Bjork, 2008).

Additionally, much of the advice offered is too vague or diluted to be practical or useful for instructional design, such as: “restructure the classroom environment to make it more inclusive rather than exclusive” (example cited without attribution by Coffield et al., 2004b, p. 37).

Second, Pashler et al. (2008) point out that the hypothesis is based on the flawed assumption that “a particular student’s having a particular preference…[implies] that optimal instruction for the student would need to take this preference into account” (p. 108), when there is no necessary, or proven, relationship between the two. In fact they go so far as to suggest that, given the rickety state of learning style research (as of 2008), assessing student style preferences is a waste of time and money, and instructional design should instead focus on content and student development.

Third, performance outcomes hinge on complex interactions of variables independent of cognitive or learning style: age, experience, gender, aptitude, prior knowledge, cultural assumptions, etc. (Ford & Chen, 2001, cited by Coffield 2004a; Pashler et al., 2008). This also raises the related question of whether assessments are an account of students’ distinct individuality, or biased by their exposure to particular curricula and teaching styles over time (Brown, Hallett, & Stoltz, 1994).

Research has demonstrated the effectiveness of the matching hypothesis in traditional teacher-led recitation learning, and with students of low ability. But, that does not address the particular requirements of specific fields (Carthey, 1993; Ford, 1999; Hunter, 1979; Matthews & Hamby, 1995; Miglietti, 1994; Pask & Scott, 1972; Raines, 1978; as cited by Yukhina, 2007). Hayes and Allinson (1997) further observed that even if matching improved learners' performance in one setting it could not prepare them for tasks in other settings. Beyond that, a literature review by Smith, Sekar and Townsend (2002) found eight studies that reported improved learning through matching, and eight studies that reported improved learning through *mismatching*.

Despite substantial advocacy for the concept by others, Coffield et al. (2004b) suggested that it is an "intuitively appealing argument which awaits empirical verification or refutation" (p. 41), and given the current state of knowledge "it is far too risky to be prescriptive about the value of individual differentiation or 'matching'" (p. 13). They also noted that there were no clear implications for pedagogy, and that "Exhortations to match or mismatch tend to be based on different ideas about the fundamental purposes of education" (p. 123).

Cross (1985) offered the alternative view that differences in cognitive style do not present a serious challenge because each student has the freedom to approach, unravel, and structure problems according to his or her particular style. Others argue for a balance of inclusive teaching methods in design education based on awareness of students' cognitive styles (Brown, Hallett, & Stoltz, 1994; Roberts, 2006, 2007; Yukhina, 2007).

Some go even further, proposing deliberate mismatching of styles to promote cognitive development and versatility. Riding and Rayner (1998) found that capable students faced with mismatched materials developed "learning strategies" that expanded their stock of skills for future problem solving. This is consistent with Vermunt's (1998) concept of "constructive friction," in which students are pushed towards autonomy. Vermunt observed that "students' use of constructive processing strategies was explained much better by self-regulation of learning than by external regulation" (p. 149). Grasha (1984, cited by Yukhina, 2007) also argued for "stretching" learners through deliberate mismatching of materials as a means to push them to expand and internalize their repertoire of strategies. Kolb (1984) echoed these sentiments, maintaining that deliberate mismatching could stimulate students to become "self-renewing and self-directed," and to focus on "integrative development" (p. 203), meaning that they become highly developed in each of the his ELT's four learning modes. These ideas are consistent with the tenets of constructivism, and also with cognitive apprenticeship's and Vygotsky's (1978) concepts of *scaffolding* and *zone of proximal development*.

Finally, transcending the fray, Glenn (2009) surmised that the hundreds of positive reports from studies of matching suggested "loosely" that students "do better when instructors are trained in learning-styles theory" (para. 18). Glenn cited Richard E. Mayer's[2] vernacular observation that, "Even though the learning-style idea might not work, it might encourage teachers to think about how their students learn and what would be the best instructional methods for a particular lesson" (para. 20). Coffield et al. (2004a) similarly concluded that learning-style instruments could be used beneficially as a tool for self-awareness and metacognition, "not only by diagnosing how people learn, but by showing them how to enhance their learning" (p. 133).

Implications for the present study. Coffield et al. (2004a) criticized learning style research as "characterized by a very large number of small-scale applications of particular models to small samples of students in specific contexts" (p. 1). This is an important criticism when research interests rest in a broad review of prominent models, and making recommendations to educational and governmental entities—as Coffield et al. were.

In contrast, the research interests of the present study *are expressly* focused on advancing knowledge about a small, purposive sample, VCD students at ASU, and not about generalizing to all groups. We acknowledge that the available instruments may not be appropriate for indiscriminate use in every field. Nor are our interests especially about the validity or reliability of the instruments since these have been thoroughly addressed

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by others (Coffield et al., 2004a; Kolb & Kolb, 2005; Peterson, Deary, & Austin, 2003, 2005a; Riding, 1991).

Cognitive style. This section reviews research literature on cognitive style theory. The first subsection focuses on cognitive style theory and its origins; the second takes up cognitive style testing and measurement, and the development of the instrument used in this study. The application of the theory and instrument to design education are reviewed in “Personal Characteristics, Performance, and Education,” p. 61.

Origins. In their taxonomy of “learning style” models and instruments, Coffield et al. (2004a) classified Riding and Cheema’s (1991) model and *Cognitive Styles Analysis* (CSA) instrument within the *cognitive structure* family of theories. Origins of these models can be traced to the most influential theorist in this group, Witkin (1962), who proposed the bipolar dimension of *field dependence/field independence* (FDI). This is a theoretical adaptation of Gestalt psychology’s *figure-ground* principle (Yiu & Saner, 2007). As the terms imply, field dependent individuals tend to respond to the whole of an environment or presentation when processing information, whereas field-independent individuals tend to distinguish details, and focus on them separately (Witkin, 1962). Coffield et al. identify ten prominent theorists in the cognitive style family, and ten different instruments that purport to measure dimensions of cognitive style.

The term *cognitive style* denotes inbuilt and persistent preferences in experiencing, perceiving, recalling, organizing, mentally representing, and processing information. These are viewed as one source of individual differences (Riding, 1991; Riding & Cheema, 1991; Roberts, 2006). Messick (1984) defined cognitive style as “characteristic self-consistencies in information processing that develop in congenial ways around underlying personality trends” (p. 61). These in turn may lead individuals to adopt particular preferences for learning and problem solving. Cognitive styles are generally conceptualized as bipolar continua representing a bias, or preference between opposing methods of information processing and representation (Hudson, 1966). Ernest and Paivio (1971, cited by Yukhina, 2007) noted that the basis of all cognitive style theories is the argument that preference is governed by ability. When an individual finds a particular mode easier and comprehensible, he is likely to resort to that mode, regardless of whether it is appropriate for a particular task.

Cognitive style theory is replete with models and instruments that address limited and specific purposes, label dimensions and constructs variously, and offer ambiguous definitions of boundaries. For example, Coffield et al. include the *cognitive structure* theoretical family within their comprehensive review of *Learning styles and pedagogy in post-16 learning* (2004a) despite the fact that theorists such as Riding contend that cognitive style dimensions are quite “fundamental and independent of learning ‘styles’ and strategies per se” (Sadler-Smith, 1997, p. 62). As a result, “there are no universal definitions for these terms and a considerable confusion in the literature as numerous authors use them interchangeably” (Yukhina, 2007, p. 9).

Features of cognitive style theory. Theorists in this group share the view that cognitive styles are structural properties of individuals’ cognitive system, related to ability, and as such are less susceptible to training or change over time. This stands in contrast to other style models such as Kolb’s Experiential Learning Theory (ELT), which propose responsive and changeable styles, or strategies, of learning. Epistemologically, cognitive style models owe much to psychoanalytic theory, and particularly the pleasure/reality principle proposed in Freud’s psychoanalytic theory. Cognitive styles are conceptualized as a mechanism for mental mediation between internal drives and external realities. Most models in the cognitive style family (as most other style models) are based on sets of bipolar dimensions that describe a manageable number of variables (Coffield et al., 2004a).

In 1991, Riding and Cheema published a survey of 30 cognitive style models advanced by others, and proposed a new model comprised of two independent dimensions:

1. Holist-Analytic (HA) – which embodies the way that individuals mentally *organize* and process information, either as a whole or in parts; and
2. Verbal-Imagery (VI) – which embodies the way that individuals mentally *represent* meaning, either as words, or as pictures. (Riding, 1991a; Riding & Rayner, 1998; Riding & Wigley, 1997)

Riding and Cheema's model reflected previous research into cognitive functioning and learning performance on a variety of tasks, and was an attempt to integrate myriad theories of cognitive style into a unified construct. They claimed that their framework accommodated the scope and theoretical features of previous models, whose differences, they also claimed, were largely a matter of labeling. Figure 7 depicts the model's dimensions and their four associated bivariate cognitive styles.

When discussing the theory and model, it is crucial to distinguish among the terms and what they represent. The words *Holist, Analytic, Verbal, and Imagery,* refer to the poles of the two dimensions; the compound words *Holist-Analytic, and Verbal-Imagery,* refer to the bipolar dimensions themselves. The compound words *Holist-Imagery, Holist-Verbal, Analytic-Verbal,* and *Analytic-Imagery,* describe to the four bivariate Cognitive Style Types, or categories, that individuals fall into based on their ratio score on the *Holist-Analytic* dimension, and on the *Verbal-Imagery* dimension.

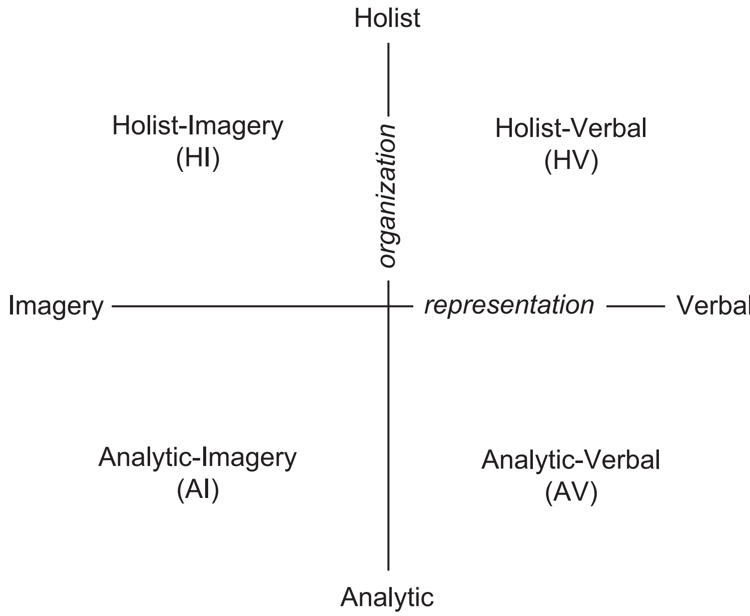

Figure 8. Riding and Cheema's two dimensions of cognitive style, and the four bivariate Style Type Groups (figure author: J. Murdock, 2010).

Table 1 summarizes Riding's taxonomy of characteristics typical of the extremities of the model's dimensions.

Table 1

Features Associated with Cognitive Style Types Proposed by Riding and Douglas.

Analytic	Holist	Imagery	Verbal
• Structured exploration • Prefer facts to concepts • Learn more easily when they can study rules sequentially • Apply step by step approach to problem solving • Feel most comfortable when they don't have to risk error as they learn or resolve problems • May feel intimidated as they fear making errors	• Impulsive synthesis • Prefer concepts to facts • Prefer having a general overview of the problem and concrete experience • Apply random, rapid, open-ended approaches to problem solving • Welcome risk and experimentation as a part of their learning or problem solving • Enjoy and benefit from communicating with others	• Mentally visualize data to conceive ideas or while thinking • Remember and understand best through watching, prefer visual data • Need visual stimulation • Usually have a strong imagination	• Represent information verbally during problem solving • Remember much of what they read, prefer verbal/written data and communication • Like to interact verbally • Have an ongoing inner dialogue which helps them remember and understand

Note. Adapted from *Cognitive abilities and learning styles in design processes and judgements of architecture students,* by E. V. Yukhina, 2007, retrieved from http://hdl.handle.net/2123/1694, March 30, 2010, p. 32. Copyright 2007 by E. V. Yukhina; and "The effect of cognitive style and mode of presentation on learning performance," by R. J. Riding and G. Douglas, 1993, *British Journal of Educational Psychology*, *63*(2). Copyright

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Development, architecture, and methodology of cognitive style instruments. The utility of theory lies in application, and that in turn relies on empirical and practical ways of measuring, quantifying, and validating theoretical constructs. Although several prominent instruments purport to measure dimensions of cognitive style, this review focuses on Riding's Cognitive Styles Analysis (CSA) and it's successor(s): Peterson's (2005) Combined Cognitive Styles Analysis (C-CSA), and Verbal Imagery Cognitive Style Test (VICS).

In combination, Peterson's C-CSA and VICS are equivalent in scope with Riding's CSA, since both contain three analogous sub-tests. In fact, Peterson's C-CSA and VICS incorporate Riding's CSA subtests. However, Peterson, Deary, and Austin (2003, 2005a) provided evidence of greater validity and reliability for Peterson's instrument(s). Based on these considerations Peterson's C-CSA and VICS were chosen for the cognitive style assessments in this study (collectively referred to as "CSA" later in this document).

Development. Coffield et al. (2004a) Identify two problems with creating instruments based on cognitive style models. The first is the failure to distinguish adequately between ability and cognitive style. That is, measurements derived from instruments may tell us more about individuals' abilities or aptitude rather than their habitual preferences for cognitive processes. This criticism is partially borne out by evidence that students with learning disabilities were more likely to be field-dependent than "average" students (Huang & Chao, 2000). However, others maintain that cognitive styles are deeply embedded in personality structure and are likely the inherent descendants of ability, making such distinctions subjective, or so fine-grained as to be unmeasurable.

The second pitfall lies in the difficulty of establishing the construct validity of the scales. The ambiguity of what is actually being measured hampers the development of test items that are clear-cut measures of cognitive style rather than level of skill, or something else (Coffield et al., 2004a).

Riding's Cognitive Styles Analysis. As of 2005, Riding's CSA was the most frequently used computerized measure of cognitive style in the United Kingdom and was also popular in European universities and organizations (Peterson et al., 2005a). Riding (1991) developed the original CSA based on cognitive style model he developed with Cheema (1991), discussed above.

Riding's CSA is a computer-based test comprised of three sub-tests. The first assesses the Visual-Imagery style dimension, the second and third sub-tests assess the Holist-Analytic dimension. The program logs scores by measuring subjects' response times to a series of simple questions. Subjects respond by pressing an appropriate key on a keyboard. In all sub-tests, half of the questions require an affirmative response (i.e. "true," "yes," "the same"), and half require a negative response (i.e. "false," "no," "different"). The number of correct responses acts only as a validity measure and not a measure of cognitive style.

On the Visual-Imagery sub-test, half of the questions are about verbal comparisons and half are about visual comparisons. All of the questions are sentences constructed with words. The Verbal comparison questions ask about the *categories* of two objects such as ''Are Skiing and Cricket the same type?'' Riding argues that this is a verbal task because the response requires the identification of a "semantic conceptual category," which is verbally abstract and cannot be represented in visual form (Riding & Wigley, 1997, p. 379-80). The Imagery comparison questions ask about comparing the *color* of two objects, e.g. ''Are Lettuce and Lawn the same color?'' Riding argues that this is an imagery task because comparing the color of two objects requires constructing mental images.

The ratio of the participant's average Verbal reaction time to their average Imagery reaction time is calculated, and the numerical value of this ratio determines the subject's position on the Visual-Imagery dimension (ibid.).

The second and third sub-tests assess the Holist-Analytic dimension (see Figure 8). The first sub-test presents items that each contain a pair of complex geometric figures that the subject is asked to judge as being the same or different. Since this task involves judgments about the overall similarity of two figures, Riding argues that a quick response would indicate a Holist propensity. The second sub-test presents items that each contain a simple *and* a complex geometric shape. The subject is required to judge whether or not the simple shape is contained in the complex one. Riding argues that a quick response indicates an Analytic propensity.

The ratio of the participant's average Holist reaction time to their average Analytic reaction time is calculated, and the value of this ratio determines the subject's position on the Holist-Analytic dimension (ibid). Figure 9 shows examples of the Holist and Analytic items.

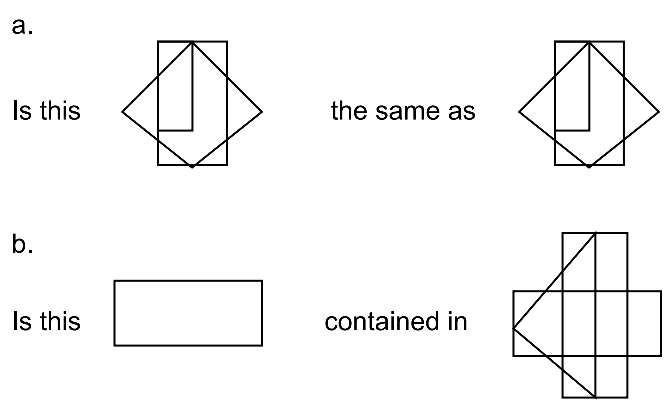

Figure 9. (a) holist, and (b) analytic, items typical of Riding's CSA Holist-Analytic sub-tests, from Peterson et al.'s CSA-B subtest. Adapted from "The reliability of Riding's Cognitive Style Analysis test," by E. R. Peterson et al., 2003, *Personality and Individual Differences*, *34*(5), p. 882, 883. Copyright 2003 by Pergamon/Elsevier. Reprinted with permission.

Unlike many instruments, the CSA generates scores from response time rather than reflective self-reporting. Subjects are not aware of the method of assessment and cannot contrive results. Riding claims that this makes the test objective. He also claims that because it positively assesses both ends of the style dimension, it is a measure of style rather than simply ability (Riding & Rayner, 1998).

Reliability and validity / Peterson's CSA. Although a substantial amount of research has been reported supporting the validity of the CSA, Riding has not published any information on the reliability of the CSA. Coffield et al. (2004a) maintained that the lack of adequate evidence of reliability makes it impossible to properly evaluate studies that address validity (remember that, by definition, a valid instrument must also be reliable). In a personal communication with Coffield, Riding argued that a test can be valid without being reliable, but offered no explanation of why, or how the CSA could be valid in one administration and not subsequently (Coffield et al., 2004a).

To investigate the issues of reliability, Peterson et al. (2003, 2005a) developed a parallel version of Riding's CSA in 2003, and followed up with a study comparing the reliability and internal stability of Riding's CSA to their new form. Using test-re-test, and split-half analysis, they found that the median reaction times, on each section of the two versions, were highly correlated, with the mean $r = 0.74$, $p < .001$, and concluded that their new version was a suitable parallel of Riding's CSA. But, they also found the test-retest reliability of both versions not statistically significant on the Visual-Imagery dimension, $r = 0.27$, and unacceptably low on the Holist-Analytic dimension, $r = 0.60$.[3]

Peterson et al. pursued their investigation by combining the items from Riding's CSA with the items from her parallel CSA, to form a double-sized, or *Combined CSA* (C-CSA) test. Split-half analysis of the C-CSA yielded a reliability coefficient of $r = 0.69$ for the Holist-Analytic dimension, meeting Kline's (2000) standard of for psychometric testing. However, the reliability coefficient for the Visual-Imagery dimension remained unacceptably low at $r = 0.36$.

[3] Kline (2000) suggested that a reliability coefficient of about r = 0.7 is the minimum requirement for a good test.

In response, Peterson et al. (2005a) developed a new test of Verbal-Imagery Cognitive Style (the VICS test). They made three logical revisions to the format of Riding's two Holist-Analytic sub-tests: (a) verbal item questions were changed from comparisons of whether two things were of the same "type," to whether two the things were "man-made" or "natural;" (b) imagery questions were changed from comparisons of whether two things were of the same "color," to whether one of the things was "bigger" in real life; and (c) each test item was duplicated and randomly presented as a separate but parallel statement composed (i) in words, and (ii) as a comparison of images. (a) and (b) above served to reduce ambiguity of interpretation, and (c) was intended to control for verbal or imagery bias, and to investigate style preferences between picture-based and word-based stimuli. Facsimiles of these items are shown in Figure 10.

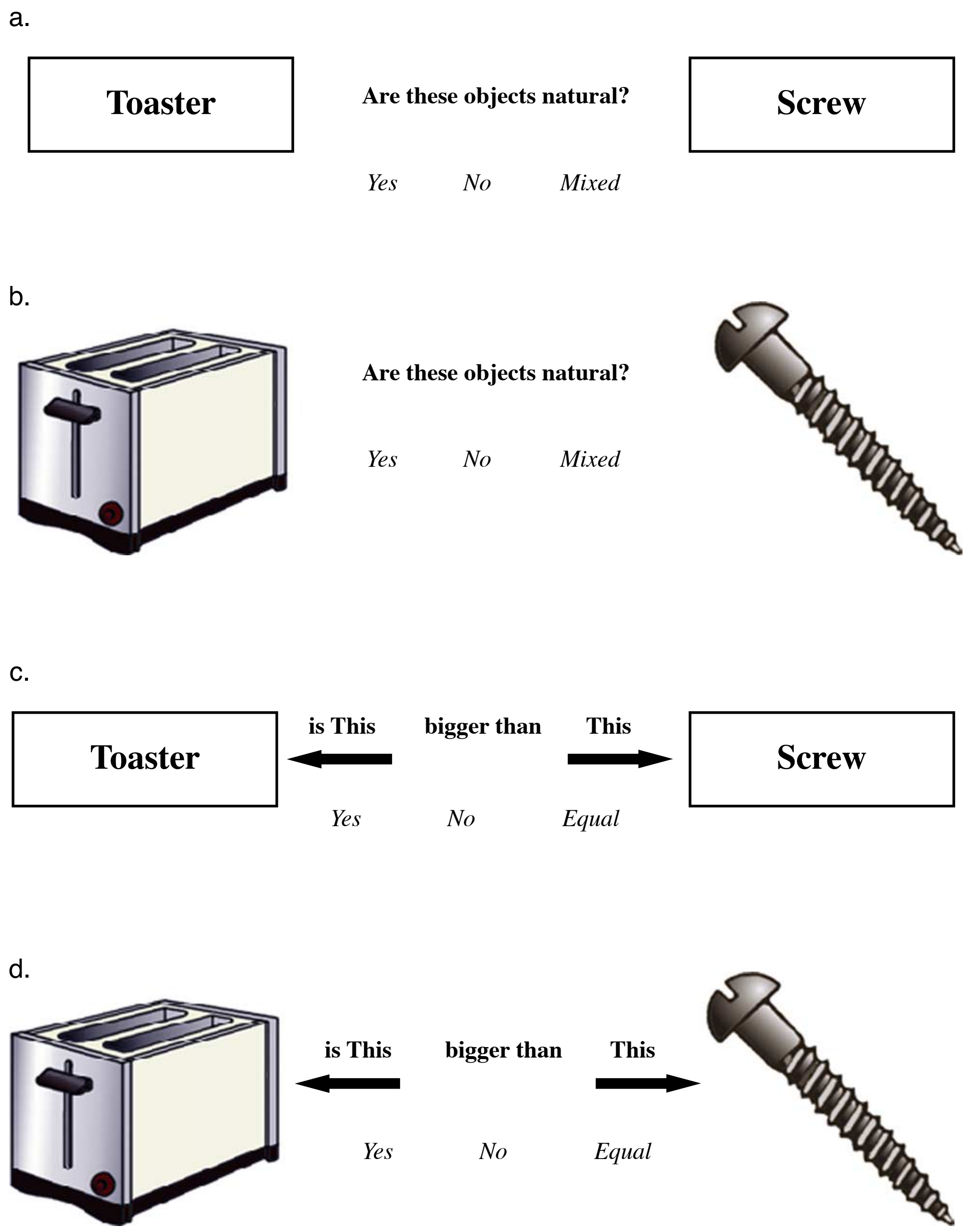

Figure 10. (a) example of a verbal item in the word form, (b) example of a verbal item in the picture form, (c) example of an imagery item in the word form, and (d) example of an imagery item in the picture form, from Peterson et al.'s VICS. Adapted from "A new measure of Verbal-Imagery Cognitive Style: VICS," by E. R. Peterson et al., 2005a, *Personality and Individual Differences*, *38*(6), p. 1273. Copyright 2005 by Pergamon/ Elsevier. Reprinted with permission.

Peterson et al. (2005a) reported that the VICS test showed high internal consistency, $r > 0.72$, and "acceptable" re-test reliability, $r = 0.56$. They concluded that the VICS was a reliable measure of the Verbal-Imagery dimension proposed by Riding and Cheema (1991).

Learning style. This section reviews research literature about learning style theory. The first subsection focuses on learning style theory and its origins; the second takes up learning style testing and measurement, and the development of the instrument used in this study. The application of the theory and instrument to design education are reviewed in the "Personal Characteristics, Performance, and Education," p. 61.

Origins. In their taxonomy of learning styles and instruments, Coffield et al. (2004a), classified Kolb's Experiential Learning Theory (ELT) and Learning Styles Inventory (LSI) within the "flexibly stable learning preferences" family of theories. The most influential theorist in this family is David Kolb, whose work has generated a large body of research since the 1970s. His theory grew out of his own experimental teaching methods, and his observations that some students showed distinct preferences for certain learning tasks and not others. Theoretically ELT is a synthesis of the works of Lewin, who proposed a four-staged model of learning, Dewey, who viewed learning as a dialectic process incorporating experience, concepts, observations, and action, and Piaget, who viewed learning as a four-stage process of cognitive growth (as cited by Kolb, 1984).

Kolb's model provided the theoretical basis for a large number of similar models and instruments. Notably, Honey and Mumford's Learning Styles Questionnaire (LSQ), McCarthy's (1990) 4MAT instructional method, and Allinson and Hayes's (1988) Cognitive Style Index (CSI), each of which incorporate elements of Kolb's theory (Coffield et al., 2004).[4] In 2000 Kolb published a bibliography containing details of 1004 research studies on the application of ELT and the LSI within the contexts of multiple disciplines. By 2004, the LSI had been translated into at least seven languages (Coffield et al., 2004).

[4] The reader will again notice the ambiguous and inconsistent use of the terms "learning" and "cognitive" in these titles—typical of the literature in the area.

Features of learning style theory. Kolb's ELT views learning as a constructivist process in which individuals create knowledge by grasping experience and transforming it. This experiential learning is based on six propositions:

1. Learning is best conceived as a process, rather than in terms of outcomes;
2. Learning is a continuous process grounded in experience—all learning is relearning. This means that learning is best facilitated by a process that draws out the students' beliefs and ideas about a topic so that they can be examined, tested, and integrated with new, more refined ideas;
3. Learning requires the resolution of conflicts between *dialectically* opposed modes of adaptation to the world;
4. Learning is a holistic process of adaptation to the world;
5. Learning involves synergetic transactions between the person and the environment;
6. Learning is the process of creating knowledge as a result of the transaction between social knowledge and personal knowledge (Kolb & Kolb, 2005a, p. 2).

Learning, by its nature, is full of tension because learners must choose among particular types of abilities, or modes they need to construct knowledge. Conflicts are resolved by choosing one of these modes, and over time learners develop preferred choices. In contrast to cognitive style models, Kolb proposed that learning styles were not fixed individual traits, but semi-stable and adaptable to situation. Thus, the ELT model actually incorporates two models: (a) a static map of learning preferences, and (b) a dynamic cycle of learning process (Coffield et al., 2004a; Kolb, 1984).

The four-stages of the ELT model are comprised of (a) concrete experience (CE), (b) reflective observation (RO), (c) abstract conceptualization (AC), and (d) active experimentation (AE) (see Figure 11). These four abilities are represented by the labels at the ends of the two independent dimensions: AC-CE, and AE-RO. These dimensions characterize individuals' preferences for (a) grasping, or perceiving experience from the environment (AC-CE), and (b) transforming, or processing, the grasped experience (AE-RO).

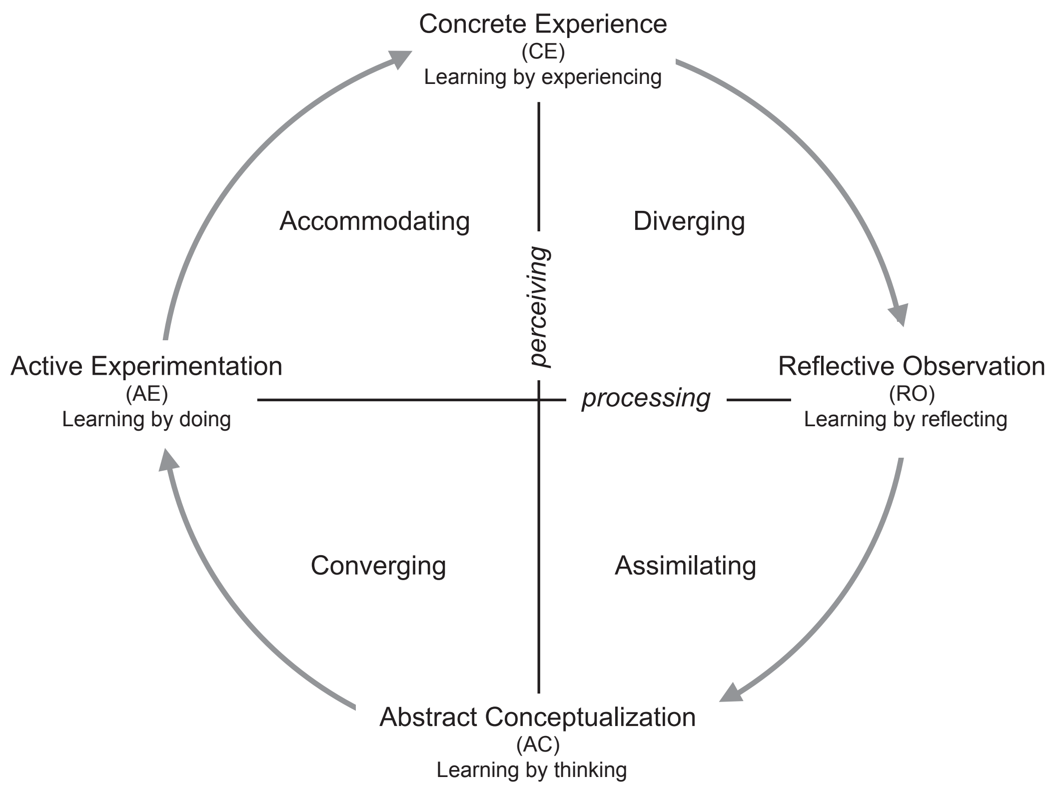

Figure 11. The Experiential Learning Theory model. Adapted from "Focus on architectural design process through learning styles," by O. Demirbas and H. Demirkan, 2003, *Design Studies*, *24*(5), p. 441. Copyright 2003 by Elsevier. Reprinted with permission.

When discussing the theory, the model, and the instrument, it is crucial to distinguish among the terms and what they represent. The terms *CE, RO, AC, and AE,* refer to the poles of the two dimensions; the compound terms *AC-CE, and AE-RO,* refer to the bipolar dimensions themselves; and the words *Accommodating, Diverging, Assimilating, and Converging,* describe the four bivariate categories that individuals fall

Table 2

Personal Characteristics Associated with the Learning Style Types Proposed by Kolb.

Accommodating (concrete, active)	**Diverging** (concrete, reflective)	**Assimilating** (abstract, reflective)	**Converging** (abstract, active)
▪ Likes doing things, carrying out plans and getting involved in new experiences ▪ Good at adapting to changing circumstances ▪ Solves problems in an intuitive, trial-and-error manner ▪ At ease with people but sometimes seen as impatient and "pushy"	▪ Is imaginative and aware of meanings and values ▪ Views concrete situations from many perspectives ▪ Adapts by observation rather than by action ▪ Interested in people and tends to be feeling-oriented	▪ Likes to reason inductively and to create theoretical models ▪ Is more concerned with ideas and abstract concepts than with people ▪ Thinks it more important that ideas be logically sound than practical	▪ Is good at problem solving, decision making and the practical application of ideas ▪ Does best in situations like conventional intelligence tests ▪ Is controlled in the expression of emotion and prefers dealing with technical problems rather than interpersonal issues

Note. A tabular adaptation of Coffield et al.'s (2004) summary of Kolb's Learning Style Types, p. 62 (table author: J. Murdock, 2010).

into based on the difference of their scores on the *AC-CE* dimension, and *AE-RO* dimension. Table 2 summarizes the personal characteristics associated with these four Types.

Development, architecture, and methodology of Kolb's LSI. The LSI was created to fulfill two purposes:

1. To serve as an educational tool to increase individuals' understanding of the process of learning from experience and their unique individual approach to learning, and
2. To provide a research tool for investigating experiential learning theory (ELT) and the characteristics of individual learning styles (Kolb & Kolb, 2005a, p. 8).

The LSI was not intended to be a predictive test such as the Stanford–Binet Intelligence Scales, SAT, GRE, or GMAT, rather it was originally developed as a self-assessment exercise and autodidactic tool, and later used as a means to assess the construct validity of ELT. However, it has found currency in educational research as a means to study differences in performance within academic programs and other uses.

In terms of mechanics, Kolb's LSI version 3.1 (used in this study) is a forced-choice sentence-completion questionnaire of 12 randomly presented items. The items are statements like "I learn best from," and the test taker ranks four endings such as "rational theories" (AC), "personal relationships" (CE), "a chance to try out and practice" (AE), or "observation" (RO), in order of preference, on a scale of one to four.

The LSI yields primary scores on the four poles: CE, RO, AC, and AE. These are then converted to scale variable scores by subtracting the CE score from the AC score, and the RO score from the AE score. This yields a score for each test taker on each of the two main dimensions (in other words, each individual's preference for abstractness versus concreteness [AC-CE], and action versus reflection [AE-RO]). Each individual's Learning Style Type is determined by the quadrant into which he or she falls, according to their bivariate scores on the AC-CE and AE-RO scales (as shown in Figure 11).

The format of the LSI is *ipsative*, meaning that it calls for an exclusive ordering of four items by the test taker on each question (in this case the four options for completing a sentence about preferences). This differs from *normative* measures, whose structure is based on independently choosing a level of preference to items (e.g. asking how much one agrees with a statement on a scale of 1 to 5), as opposed to ranking one choice higher or lower than others.

Critics have argued that ipsative measures generate data that are inappropriate for parametric statistics because the data are at an ordinal level of measurement—they lack the interval level required for parametric analysis. Also, that such data cannot be used for comparisons between individuals, because forced comparisons are not independent preferences, but preferences relative to the other response items in the set

(Baron, 1996; Karpatschof & Elkjaer, 2000; Kolb & Kolb, 2005a).

Kolb countered that the ipsative format is appropriate because it more accurately reflects real-world choice-making. He also pointed out that while the four primary scores of the LSI are ipsative, the combination scores (AC-CE and AE-RO) are scale variables, not ipsative, and thus afford comparisons among individuals. And that “ELT argues that a given learning mode preference is relative to the other three modes, it is the comparison of relative not absolute preferences that the theory seeks to assess” (Kolb & Kolb, 2005a, p. 11).

Reliability and validity. The LSI 3.1 was based on new norms drawn from a larger, more diverse, and more representative population sample of 6977 people. Kolb and Kolb provided an extensive review of the vast body of criticism, and research findings in their (2005a) publication: *Kolb Learning Style Inventory – Version 3.1: 2005 Technical Specifications*. In addition, Veres, Sims and Locklear (1991, cited by Kolb & Kolb, 2005a), in a study of the LSI 2.0, found that randomly changing the presenting order of the sentence ending choices (to counter *response bias*), dramatically increased test-retest reliability; the LSI 3.1 also incorporated this change.

Seven studies of the LSI 3.1 reported Cronbach’s alpha coefficients that “suggest that the LSI 3.1 show[s] good internal consistency and reliability across a number of different populations” (Kolb & Kolb, 2005a, p. 15). Two studies of test-retest reliability reported correlation coefficients that ranged from “moderate to excellent” (p. 16). Kolb and Kolb defended low coefficients in one of these studies by arguing that styles are interdependent and situationally variable, not fixed, which is consistent with ELT’s contention that learning styles evolve in response to career choice and life experience.

Correlation and factor analysis studies of internal validity and construct validity provide “qualified support for the ELT basis for the inventories” (p. 23). The qualification was necessary because of higher-than-predicted negative correlations between AC and

AE, and CE and RO in the LSI 3.1 normative sample. However, the authors concluded that “Judged by the standards of construct validity, ELT [and therefore the LSI] has been widely accepted as a useful framework for learning-centered educational innovation, including instructional design, curriculum development, and life-long learning” (p. 21).

Research on external validity—the ability of an instrument to generalize to various populations—is peppered with studies equal in positive and negative support (Coffield et al., 2004). Kolb and Kolb (2005a) offer a general survey of studies, but do not directly address the issue of external validity with the specificity in which they address internal validity, construct validity, and reliability. They provide no specific statistics, nor any definite conclusion.

Generalizing to other populations, however, is not a research interest of the present study. And the findings cited above provide sufficient evidence for the validity and reasonable reliability of the LSI 3.1 to justify its use in the present study and in the analogous studies cited in subsequent sections.

Cognitive Apprenticeship

Collins et al. (1991) proposed a *cognitive apprenticeship* (CA) model of learning that is adaptable to various disciplines whose core is complex ill-defined problem-solving. This approach is introduced and reviewed here because of its usefulness as a formal structure and lexicon for the methods implicit in studio-based VCD education. This subsection summarizes the approach. Examples of the principles of CA applied to education and VCD education is offered in the next chapter, “Personal characteristics. performance, and education” (p. “Personal Characteristics, Performance, and Education” on page 61).

Structure and constructs. Using traditional apprenticeship as a basis, Collins et al. developed a framework for designing learning environments that promote cognitive development and complex problem solving skills. The framework can be modified to address the needs of specific domains. As such, the system involves many carefully arranged principles which can receive particular emphasis or treatment depending on context.

CA can be considered both an eclectic, and a constructivist approach. It is also clearly a descendant and elaboration of Vygotsky's social constructivist theory. The two approaches share common constructs, methods, and terminology. In the interest of conciseness, this subsection mainly presents the principles in outline form with brief definitions.

Collins et al. (1991) identify three activities that distinguish traditional apprenticeship: (a) *modeling*, (b) *scaffolding* and *fading*, and (c) *coaching*. In modeling, the teacher performs a task so students can observe the process and emulate it. Scaffolding involves the teacher providing sufficient support for learners to perform a task that is too advanced for them to perform independently. Part of the scaffolding process is fading—the process of gradually withdrawing support as learners become increasingly competent and achieve independence. Coaching is the general process of overseeing students learning: offering hints, evaluations, direction—the "envelope" within which the other methods are facilitated.

In addition, Collins et al. called attention to the key role played by observation, since it helps learners develop a *conceptual model* of a task (Lave, 1988, as cited by Collins et al, 1991). Conceptual models assist beginners in four ways:

1. They provide an advanced organizer. This allows the learners to see where they are going and to concentrate on tasks because they understand the task within the context of the goal;
2. They provide a structure for interpreting feedback;
3. They provide an internalized guide for learners when they are acting independently;

4. They encourage autonomy by allowing learners to reflect and continuously update their internal understanding.

Collins et al. also emphasize that apprenticeship encourages cognitive development because it is embedded in a social subculture where learners “have continual access to models of expertise-in-use against which to refine their understanding of complex skills” (p. 2).

Although CA draws on the craft apprenticeship tradition it primarily focuses on developing cognitive, metacognitive, and problem-solving skills, rather than tangible physical skills. Collins et al. point to three distinctions between traditional apprenticeship and CA.

1. In traditional apprenticeship learners can literally see the processes by which a product is created, for example a garment or cabinet. On the other hand, in abstract creative-problem-solving these processes are mental and invisible. Thus, In order to teach cognitive methods for problem solving the teacher’s thought processes of the must somehow be made visible to the students, and those of the students visible to the teacher.
2. Traditional apprenticeship centers around creating tangible products in a specific workplace. The value of the product is an obvious example of the steps necessary to create it. However, the cognitive steps of advanced problem-solving are typically abstract and non-linear—not obviously consequential to the solution. There is less direct connection between the problem-solving steps and final solution, and the steps also may have little to do with the routines typically encountered in daily life. The task of CA therefore is to situate learning within a context that is authentic and meaningful to students.
3. In traditional apprenticeship the tasks and content learned are specific to a

particular domain. For example, an apprentice cabinetmaker is not taught how to hem garments. There is no imperative to transfer knowledge to other domains. On the other hand, creative problem-solving demands that students learn to generalize (or *decontextualize*) and transfer cognitive strategies to novel problems and between domains.

Based on their observations and analyses of successful learning programs, Collins et al. developed a "Framework for Designing Learning Environments," that consists of "four dimensions that constitute any learning environment: content, method, sequence, and sociology" (p. 12). Each of these dimensions is comprised of several components that are summarized below:

- *Content* is the kinds of knowledge required for expertise.
    - *Domain knowledge*. These are the concepts, facts, and procedures that are specific to a discipline.
    - *Heuristic strategies* are generally effective techniques for accomplishing tasks. They might be regarded as tactics, or "tricks of the trade."
    - *Control strategies* also known as metacognitive strategies, are the way learners select among approaches and how they decide when to change approaches. These involve monitoring, diagnosing, and remediating the process in terms of the goals.
    - *Learning strategies* are methods for acquiring any of the other content described above—how to learn new concepts, facts, and procedures.
- *Method(s)* are teaching techniques. These fall into three groups. The first three (modeling, coaching, and scaffolding) are at the core of apprenticeship, as discussed above. The next two (articulation and reflection) help learners focus their observations and become conscious of their own strategies. The last

(exploration) encourages learners to become autonomous and to constructively define and formulate new problems.

- *Modeling*. The teacher performs a task, or demonstrates a solution, so students can observe the process.
- *Coaching*. The teacher observes and facilitates while students perform tasks.
- *Scaffolding*. The teacher provides support and helps students perform tasks, then *fades*, or withdraws, the support as students gain competency.
- *Articulation*. Students learn to verbalize their knowledge and thinking strategies. This develops students' ability to create formal and explicit structures of problems and solutions. In VCD this is one of the functions of group critiques, and group projects.
- *Reflection* enables students to compare their performance to that of experts and peers. One technique to enhance reflection is "replaying," or reproducing, previous successful paths to solutions from experts and novices, in order to compare and highlight critical features.
- *Exploration* is the consequence and goal of scaffolding and fading. It involves setting general goals and then encouraging students to examine sub-goals. This refines students' strategies, pushes them towards independence, and encourages them to pose and solve their own problems. It also promotes the interests of decontextualizing cognitive expertise (i.e. the ability to generalize strategies and apply them to novel problems).

- *Sequencing* provides the keys to effectively structuring learning activities and preserving the meaningfulness of students' experience.

    - *Global before local skills* teaches students to build a conceptual model of the whole task before executing its parts. This provides a road map and foundation for understanding goals, and a context for monitoring progress. This is also consistent with the sequence in traditional design education that begins with training in fundamentals.
    - *Increasing complexity* follows from the previous concept—meaningful tasks gradually increase in difficulty and autonomy. The two key mechanisms involved are (a) sequential control of task complexity, and (b) scaffolding.
    - *Increasing diversity* means sequencing tasks to require an increasingly wider variety of approaches and practice in various situations. This contributes to decontextualizing knowledge and tactics.
- *Sociology* refers to the social characteristics of learning environments: organized social settings where students are surrounded by experts and peers.
    - *Situated learning* places students in a setting where particular activities take place, and in which they work on realistic tasks. This advances their understanding of why and what they are learning, which strategies are appropriate to situations, and how to transfer their knowledge to different contexts.
    - *Community of practice* creates a learning environment in which participants actively communicate about different ways to accomplish tasks. This fosters a sense of ownership as well as interdependence.
    - *Intrinsic motivation.* The learning environment fosters students' personal motives to achieve excellence, rather than extrinsic motives such as getting a good grade.
    - *Cooperation* means that students work together to problem-solve and

achieve goals. This may also take the form of group competition. (paraphrased from Collins et al., 1991, pp. 12-16)

Collins et al. point out that although CA is intended to teach the processes that experts use in solving problems and carrying out complex tasks by making those processes visible to learners, it is not the only way to learn, nor is it appropriate for every learning task. And importantly, “Ultimately, it is up to the teacher to identify ways in which cognitive apprenticeship can work in his or her own domain of teaching” (p. 17). To this end Collins et al. offer three examples of successful learning programs, authored by others, that exemplify the principles of CA. An example of this framework within the context of VCD education is reviewed in the “Cognitive Apprenticeship in Education and VCD Education” section of this chapter, p. 87.

Personal Characteristics, Performance, and Education

This section examines literature specific to the present study’s dependent variables. The material covered here elaborates on topics that have previously been introduced or touched on. The function of this section is to present details that tie the previous review of theoretical literature to the findings and opportunities, research questions, results, and discussion that follow.

This section begins with a review of literature on prior academic achievement as a predictor of future success. Second, it turns to literature about cognitive style research in design education, third, learning style research in design education, and finally a summary and conclusion.

Academic Performance.

The present study examines several aspects of prior academic performance, as measured by grade point average (GPA), as a predictor of future success in a VCD program. Considerable evidence supports the view that prior GPA is a valid predictor of future GPA, but some take issue with interpreting GPA alone as evidence of learning and development (Astin, 1991; Heywood, 1999; Jansen & Bruinsma, 2005; Messick, 1999).

Wilson (1983), following an extensive literature review, concluded that standard ability tests and high school GPA were both valid predictors of freshman year GPA, and long-term cumulative GPA. But freshman GPA tended to have higher validity for predicting post-freshman GPA than standardized tests. The best predictor of GPA in any given semester was previous cumulative GPA. Minear (1998) cited five studies that reported predictive relationships between high school GPA and persistence and dropout rates in Bachelor of Arts degree programs, lending support for the predictive value of GPA. Jansen and Bruinsma (2005) used self-report questionnaires and prior academic achievement data to investigate students' pre-entry characteristics as predictors of academic achievement in the first year of university. They too, found that pre-university GPA was the most "important" predictor of achievement. Interestingly though, they also concluded that "The use of deep information processing strategies did not result in higher grades" (p. 235).

Garavalia and Gredler (2002) studied college students' learning strategies. They found that prior grades contributed 13.66% to predicting later achievement, an amount beyond that accounted for by any other variable they studied. Finally, Klomegah (2007) examined seven variables as predictors of undergraduate academic performance, and found that high school GPA and student self-efficacy were strongly correlated with performance. Their multiple regression analysis revealed high school GPA as the best overall predictor.

The literature also furnishes evidence that prior academic achievement is a significant predictor of accomplishment in professional life. Baird (1985), in a wide-ranging literature review, concluded that academic ability plays two roles in achieving professional status and income. The first is direct: the higher one scores on academic ability tests, the higher one's academic attainment. The second is indirect: because of selection criteria, individuals with high scores end up with more years of education, which results in greater personal accomplishments. Baird concluded, “In sum, there is much evidence that more academically able people are more ‘successful,’ in terms of economic and occupational attainment than less academically able people” (p. 67). He also noted several studies that indicated that specific abilities or skills in particular fields were more predictive of success in those fields than test scores of general academic ability.

However, while prior GPA may be the best predictor of future GPA, other authors have argued that it is not necessarily a measure of development or learning. For example, Harris (1970) compared students’ grades in a specific course with “actual learning” in the course, as measured by scores on alternative tests given before and after the course. On the basis of those scores he concluded that students with failing, or near-failing grades in the course made learning gains comparable to students with high grades in the course. Harris reasoned that, although grades report how students perform relative to one another, they do not report in an absolute sense how much learning has taken place individually.

Astin, (1979) made the argument that the preoccupation with ranking students from “best” to “worst” is an artifact of a business model that is not appropriate for education. Institutions of learning exist to develop talent, not just act as a “funnel” that maximizes output that subordinates concerns about student growth and development. Astin (1991) proposed that there may only be a correlation, rather than a predictive relationship, between high school GPA and college GPA, and that simply using GPA as a criterion for selective admission does not necessarily further the developmental aims of higher education. As an illustration, he suggested that if all students entering college were put in a state of suspended animation for four years, then revived and given final exams, the students with the best grades before entry would still outperform those with the poorest grades—even though no learning had taken place. It could not be interpreted that high performers actually showed more development than low performers.

Terenzini (1999), focused on the gap between pedagogical practices (e.g. grading) and substantive learning, and pointed out: “Long-term retention of what has been learned, and the ability to apply it to somewhat different, but related, problems, or in different settings, also require reflection. Reflection permits the consolidation, the internalization, the ‘deeper learning’ we seek to facilitate” (p. 35). His observation echoes the tenets of CA, discussed in the last chapter. Jansen and Bruinsma (2005) elaborated on this, remarking that students are characteristically satisfied with “surface” learning because of their preoccupation with teaching procedures and assessment, rather than content.

The foregoing are also important considerations in view of the results of the present study, which indicate that cumulative GPA was not a significant predictor of performance in the VCD program under scrutiny (see “RESULTS,” p. 113).

Cognitive Style Research in Design Education

The literature reviewed in the this subsection was chosen on the basis of its relevance to the research problem and variables, and on the frequency of citations.[5] The search revealed no studies that specifically used Peterson’s CSA in design education research, so we reviewed studies that used the closely-related Riding CSA, and instruments whose constructs furnish similar perspectives and characteristics with Riding’s constructs. In addition, cognitive style research in design education has focused primarily on architecture—as of this writing there are no such studies of VCD programs. However, since traditional architecture and VCD programs are structurally related, and

[5] The literature is rather limited: a search in the *Academic Search Premier* (EBSCOhost) database using the using the terms “graphic design” AND “cognitive style,” “visual communication” AND “cognitive style” yielded no documents. A search in the *Dissertations and Theses* database on ProQuest using the same terms yielded only one dissertation that dealt directly with learning style as a variable in academic performance in visual communication design. Similar search findings apply to the subsection on learning style research in design education.

share a common history and project-based studio curriculum, these studies were thought to provide the best available research relevant to our study.

Cognitive style preferences and performance.

Roberts (2006) investigated the relationship between Riding and Cheema's (1991) Holist-Analytic dimension and performance on design-project work. The participants were two cohorts of architecture students at the Welsh School of Architecture (*N* = 120), and the study took place over three years.

Roberts cited Durling, Cross, and Johnson's (1996) assertion that design, architecture, and fine art students tended to show a bias towards an intuitive (i.e. Holist) approach to problem solving. He also noted other research that suggested architecture students were generally field-dependent. Roberts' goal was:

> ...to determine whether cognitive style has an impact at any particular stage of the students' development as designers…[and] whether any of the cognitive style groups had improved or declined in performance between the end of their first year and the end of their third year. (p. 173)

In addition, he was curious about the distribution of the Holist-Analytic types of his sample relative to the general population.

Using Riding's CSA's Holist-Analytic sub-test, Roberts categorized his students as Holist, Intermediate, or Analytic based on the split points established by Riding's (1998) normative sample of 1448 secondary school pupils aged 14–16.[6] Then each student was assigned a percentile rank within his or her cohort based on performance on design project work. Students were evaluated at the end of the first, second, and third years, which represented "significant mileposts in the students' development as designers, and…distinct phases within the education of an architect" (p. 170).

Using Riding's 1998 split points, Roberts found that 58% of his architecture students fell within the Analytic category. A chi-square goodness of fit test revealed that

[6] Holist ≤ 0.91, Intermediate 0.92 - 1.18, Analytic: ≥ 1.19 (Riding, 1998, cited by Roberts, 2006, p. 173)

this high proportion of Analytics was “highly significant,” with $p < .001$. Roberts speculated that “this may be a reflection of the admissions process, or possibly the secondary education system filtering out wholists [sic]” (p. 172).

Because Riding’s split points resulted in low numbers of students in some of the Style Types, which would likely lead to inaccuracies in data analysis, Roberts split his sample into three groups of statistically equivalent frequencies, using split points based on his sample’s median scores (similar to the procedure used in the present study). He then used the non-parametric Kruskal–Wallace-*H* test to test for differences in performance between the ranks of each of the three groups. Following this he used repeated measures *t* tests to compare the percentile-ranks of students in each of the groups at the end of the first and third years to test for changes in ranking over time. He acknowledges that this was problematic since “such tests refer to changes in rank position within the individual group, rather than with respect to the cohort as a whole.” But, “it was felt that a related samples t-test [sic] was sufficiently robust to be useful even with ranked data” (p. 174).

In the first cohort his findings revealed, surprisingly, that the Analytic group outperformed both the Intermediate and Holist groups in the first year. But the three groups’ mean rank converged by the end of the third year due to a significant decline in the mean position of the Analytic group. In the second cohort Analytics also outperformed the other groups in the first year, but not significantly, however the decline in performance of the Analytics between the first and third year was again significant. Figure 12 portrays the performance progress of the two cohorts. Graphically there appears to be a dramatic increase in the performance of the Intermediate group in the second cohort, nevertheless it was not significant.

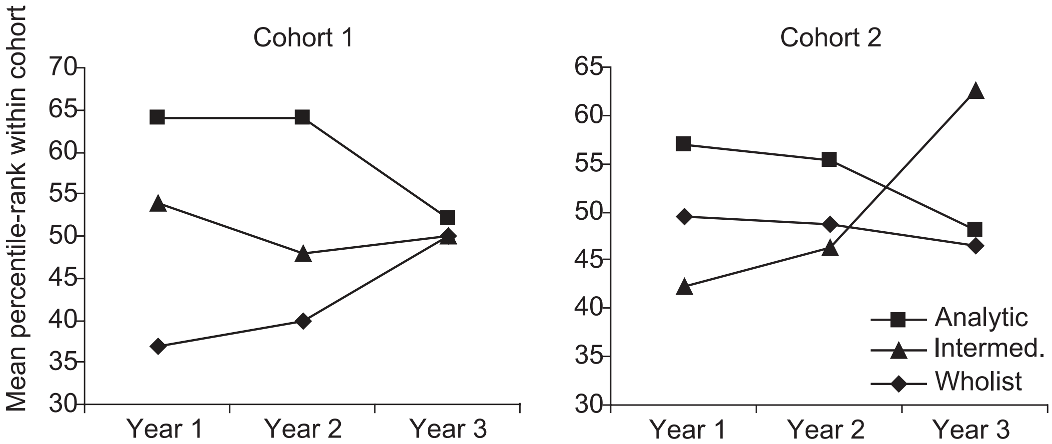

Figure 12. Performance ranks of Roberts's architecture students. Adapted from "Cognitive styles and student progression in architectural design education," by A. Roberts, 2006, *Design Studies*, *27*(2), pp. 175, 176. Copyright 2006 by Pergamon/ Elsevier. Reprinted with permission.

Roberts also noted that over 58% of the Holists in the first cohort dropped out by the third year. He speculated that this may have been caused by particular teaching and learning activities that presented greater challenges for Holists than for the other types. He reasoned further that Analytics "benefitted from the tight framework provided in the first year, but found the more open-ended structures that they encountered subsequently more challenging" (p. 178). In interviews, Analytics indicated that they felt less comfortable with the open-ended format of second- and third-year projects, while Holists and Intermediates felt overly constrained by the greater structure of the first-year projects.

Roberts concluded that his findings provided no evidence for the assertion that Holist students have an advantage in solving ill-defined design problems. In fact his results suggested the opposite: Analytic students performed better, especially in the first year. He also observed that students in the Intermediate group tended to perform consistently throughout the program, possibly as a result of the ease of accessing, or moving between, different modes of thinking.

Roberts (2007) conducted a second longitudinal study of three cohorts of architecture students (*N* = 202), this time using both dimensions of Riding and Cheema's model (Holist-Analytic and Verbal-Imagery), with the additional variables: spacial ability, performance in secondary education, and gender, as predictors of future performance in an architecture program. He was specifically interested in identifying predictors for screening students for admission to the architecture program.

This time Roberts used single sample *t*-tests to compare the mean ratios on each dimension, of each sample. He again found his sample significantly more Analytic than Riding's 1998 normative sample of secondary school pupils, and also Riding's 1991 normative sample of the UK population aged 11–65. On the Verbal-Imagery dimension he found a small, but significant, preference for Imagery.

Roberts' use of *t*-tests, rather than chi square goodness-of-fit tests of group frequencies based on split points, allowed him to avoid ambiguities of comparison made in several similar studies (see "Learning Style Research in Design Education," p. 74). The authors of the present study adopted this method.

An ANOVA showed no significant differences between mean performance scores for any of the variables. He did, however, find evidence that students with particular cognitive styles were less likely to persist in the program (i.e. they dropped out), particularly Verbal students, and female Holist students.

Yukhina (2007) investigated correlations between the variables: cognitive abilities, cognitive styles, gender, creativity, academic performance, design process, and design product, in a multifaceted study of architecture students (*N* = 80 [7]) at Sidney University. The study consisted of six "experiments" using various measurement instruments and protocols.

The portion of Yukhina's work relevant to the present study used Dun and

[7] However, participants were variously assigned to different experimental groups with smaller *n*s.

Prashnig's Learning Style Analysis (LSA) to assess a group of first-, fourth-, and fifth-year architecture students (*N* = 20; *n* = 10, 4, and 6, respectively). The LSA is a self-reporting instrument, that despite its name, includes measures on two dimensions that are conceptually consistent with (though more complex than) the CSA's Holist-Analytic and Verbal-Imagery cognitive style constructs.[8]

On the Holist-Analytic dimension first-year students indicated "preferences" and "strong preferences" of 30% Holist and 40% Analytic. However, 60% were also categorized as Versatile, indicating their ability to make good use of both styles. Among fourth- and fifth-year students, 40% were Holist, 70% Analytic, and 80% Versatile. According to Yukhina, his indicated a shift in style preferences towards Analytic and Versatile as students remain in design education.[9]

On the Verbal-Visual dimension, first-year students' preferences were 30% Verbal, 50% Visual, and 70% Versatile. The fourth- and fifth-year students' preferences were 40% Verbal, 60% Visual, and 80% Versatile, Indicating a small shift towards a Versatile style.

Yukhina found academic performance correlated with Visual for first-year students, and with Holist and Visual for the fourth- and fifth-years. In first-, as well as in fourth- and fifth-year students, Visual and Holist students were significantly more successful than Verbal students in performance on design projects. She asserts that this is consistent with other research that found Visual learners did better when material is presented in pictorial, or in text plus picture format—akin to the format of project work in architecture and visual design—whereas Verbal learners tended to perform better with

[8] The LSA uses the term "Visual" rather than "Imagery," and in our review we have distilled Dunn and Prashnig's compound formulations to their abstemious American English counterparts (i.e. "Wholistic/Simultaneous" and "Wholistic/Impulsive" condense to "Holist"). Also, note that scores on the LSA's dimensions are non-exclusive, meaning for example, that an individual can show a strong preference for both Holist and Analytic. Hence, the percentages reported may sum to greater than 100%.

[9] This finding is a bit confusing since Dunn's view of "learning" styles regards them as relatively stable.

a text or auditory format (Riding & Ashmore, 1980; Riding, Buckle, Thompson & Hagger, 1989; Riding & Douglas, 1993; Riding & Watts, 1997; as cited by Yukhina, 2007).

Yukhina concluded overall that Holist-Visual learners demonstrated the greatest creativity while Visual learners demonstrated the greatest academic achievement. Moreover, Verbal learners demonstrated a significant disadvantage in design project work. But importantly, she found "the top students across the sample were Versatile or Brain-gifted,[10] that is, potentially more able to cope in any learning environment, or more flexible in adopting different approaches to problem solving" (p. 106).

Cognitive style and instructional design. There is a persistent current of thought among style-type and personality-type theorists and researchers that the design disciplines are somehow cognitively connected with the fine arts, that practitioners in these domains are cognitively similar, and that they are typically intuitive, holistic, visual, and feeling-oriented (Coffield, et al., 2004a; Durling, Cross, & Johnson, 1996). Superficially this view has intuitive appeal, but it generally does not stand up to critical analysis, nor sufficiently recognize, or account for important differences between disciplines.

Broad concepts like "art," "design," "creativity," etc., may in fact, be defined narrowly and distinctly in the context of different domains. For example, VCD and fine-art painting are both "visual," but their purposes, business orientations, and the personal goals of their practitioners are seldom similar. Along these lines, Cross (2004) warned "Conventional wisdom about the nature of problem-solving expertise seems often to be contradicted by the behaviour of expert designers. In design education, we must therefore be very wary about importing models of behaviour from other fields" (p. 440).

The criticism also applies to the use of terms such as "design," "designers," and "arts-based" when applied indiscriminately to different samples or populations.

[10] These are also terms used in the LSA: brain-gifted people have preferences and/or strong preferences in all areas, versatile learners do not have non-preferences (i.e. learning styles which they cannot utilize efficiently or prefer to never use).

For example, is performance on “2D drafting and design tasks in digital media” by sophomore architecture students at Bilkent University, Ankara Turkey (the criterion variable in Petkas’s 2008 study, p. 63) comparable to performance on “three design and three electronic [computer-based learning] modules” by thirty trainee teachers in an Initial Teacher Training Design and Technology Education degree program at a university in Northeast England (the criterion variable in Atkinson’s 2006 study, p. 193)? Yet each of the authors in the preceding example used “design” as a sufficient descriptor of students’ activity within their study. But it is patently clear that substantial differences exist between the subject groups and area of inquiry. There is no shortage of comparable examples.

In addition to the conclusions about preferences and performance offered by Roberts (2006, 2007) and Yukhina (2007). The following studies illustrate the complexities researchers face in distinguishing between what appear to be conflicting (or supportive) findings and what may in fact be matters of semantics and definition. These raise serious concerns about the validity of the matching hypothesis as a basis for instructional design since it appears that fine-grained distinctions between concepts, terms, and other misunderstandings, may result in profoundly different instructional approaches and outcomes for students.

Durling, Cross, and Johnson (1996) reviewed studies that used the Myers-Briggs Type Indicator (MBTI), a personality typing inventory, to determine the predominant thinking styles of people in various occupations and disciplines. They found that nearly 80% of “arts based” students preferred an Intuitive thinking style (an MBTI construct) compared to business students, engineering students, and the general population. A controlled study by Lawson (1993, cited by Yukhina, 2007), also found that architecture students adopted an “intuitive” approach in a problem solving task. Pektas (2008) maintained that these findings supported the idea that Holists, rather than Analytics, might be more successful in “design tasks,” and that individuals who tended to “think with images” rather than to “think with words” were likely to be more “creative in the design process” (p. 73). Along similar lines, several researchers suggested that architecture students are more field-dependent and global (analogous to Riding’s Holist style) than other students, and that a tolerance for uncertainty and ambiguity in solving problems may be related to cognitive style (Peterson & Sweitzer, 1973; Witkin, 1962, as cited by Yukhina). But in a seemingly contrary finding, Morris and Bergrum (1978) presented evidence that architecture students were more field-independent (Analytic) than business students, a finding that appears to contradict the conclusions of the authors cited earlier in this paragraph.

Hudson (1966), whose cognitive style model is based on the construct of *Convergent-Divergent* [11] thinking—analogous to Riding’s Holist-Analytic dimension—scrutinized the matching hypothesis more directly. He researched career choices among sixth-form students in the United Kingdom, and concluded that Convergers (analogous to Riding’s Analytics) tended to pursue “science-based” subjects, while Divergers (analogous to Riding’s Holists) tended to pursue “art-based” subjects. In a later study, that seems to support the matching hypothesis, Hudson (1966), found that students at a London teaching hospital reported better learning outcomes when they were matched with teachers having the same Convergent or Divergent style.

Yukhina (2007) stated “there is no universal schema of design learning that can accommodate all designers” (p. 87), and that her research only partly supported assertions that architecture students were chiefly Holist and Visual. She found a greater percentage of Flexible and Versatile learners—those that move easily between stylistic modes—than any other group in her sample.

In an attempt at synthesis, she hypothesized that Versatile learners with a strong Analytic preference may have an advantage over Holist learners lacking Analytic

[11] Hudson’s terms represent a distinctly different concept than the same terms used in Kolb’s Experiential Learning Theory, discussed in “Learning-Style Based Theory and Models,” p. 27.

ability. Furthermore, Visual capability may compensate for the absence of Holism among Analytic-Visualizers, and Verbal capability may compensate for the absence of Analytic among Holist-Verbalizers. In other words a variety of styles may be advantageous when acting in a combined, and coordinated fashion. Moreover Yukhina suggested that individuals' styles should be considered as a continua of combinations, ordered from Holist-Visual to Analytic-Verbal—even though the Holist-Analytic and Verbal-Visual dimensions are not correlated in the cognitive style models she examined.

She concluded that instead of quibbling over matching teaching to a consummate style, it would make more sense to recognize that different areas of design education are associated with different styles. Design process itself calls for diverse proficiencies, aptitudes, technologies, and disciplines, and therefore is addressed best by teaching to a repertoire of appropriate styles:

> Given the complexity of design- and architecture-related exercises, it is almost necessary to be highly flexible in thinking styles. Being strictly wholistic [sic] or strictly analytic, only reflective or always spontaneous is not sufficient for achieving good academic results in a range of architecture-related courses. Similarly, it is important to be flexible in both visual and verbal modalities to fulfil a variety of requirements architectural educations [sic] sets for its students. It is not surprising, therefore, that no learner fits neatly into one particular style, but, rather, has a range of styles, although may be inclined towards one area more than another. (p. 89)

Summary and Conclusion. The literature reviewed in this section reviewed findings from studies of cognitive style in education and design education related to the aims of the present study. Researchers reported conflicting findings in studies of different groups of students, but these specifics cannot be adequately distinguished from the influence of unacknowledged variables, assumptions and definitions about what is being measured, and the different characteristics of various samples.

Despite arguments in favor of the matching hypothesis, the studies reviewed tend to support the proposition that all cognitive styles are represented in design studio education; extreme preferences do not have a consistent advantage; and that learners with versatile, or undifferentiated cognitive style preferences may have a greater adaptability to learning that is reflected in an advantage in performance and persistence.

The foregoing review revealed both the complexities of cognitive style research and some of its numerous pitfalls. A comprehensive synthesis of different models is absent the discipline, due in part to the plethora of models and labels, an overall lack of robust evidence for the validity and reliability of instruments, and disagreement on basic issues such as: how styles are formed, how stable they are, and what role ability plays in learning. The foregoing also illustrates the paradox of modeling the evasive workings of the mind in areas that are difficult to measure and quantify (Coffield et al., 2004a; Riding & Cheema, 1991; Riding & Rayner, 1998).

Learning Style Research in Design Education

Kolb’s LSI 3.1 has been used in numerous research studies since 2005. The few studies that specifically address design education, or research questions similar to the present study, primarily focus on architecture programs, and use prior versions of the LSI. The present literature search found no such studies of VCD programs, and thus, the studies reviewed provide the most relevant research to inform the present study. However, that assumption carries with it a number of limitations for validity, and in addition each study reviewed has its own internal assumptions and limitations.

Learning style preferences and performance.

Demirbas and Demirkan (2003) used the LSI 3.0 (Kolb, 1999) to study 88 freshman architecture students’ performance on a single design project. The authors found that students with various learning styles performed differently on different stages of the project.

The students were asked to design a staircase for a three story house to particular specifications. Each of the four stages of the project were evaluated as a separate performance outcome. Stage 1 required students to research staircases and produce a written report. In Stage 2 they attended a lecture and discussion on staircase design and were taught rules of technical drawing. They were then supplied with orthographic and section drawings of the house and instructed to develop four preliminary scale drawings showing the design and location of the staircase within the house. Stage 3 had the students construct a scale model according to their drawings from stage 2. Stage 4 was essentially a repetition of stage 2—the students again were asked to create four scale drawings, refining the design based on their previous work, to test the expectation that their performance would improve. The students' learning styles were assessed prior to the study, but were not apprised of their Learning Style Types until after the study was completed in order to control for any information that might bias their approach.

The authors reported that the majority of students fell into the Converging and Assimilating groups with the Accommodating group the having the lowest frequency. We assume that the authors used the normative split points from the LSI 3.0 to divide their sample into Style Type groups, but they did not specify these points. Nor did they report the significance of any differences in group frequencies. Figure 13 shows the distribution of the cases.

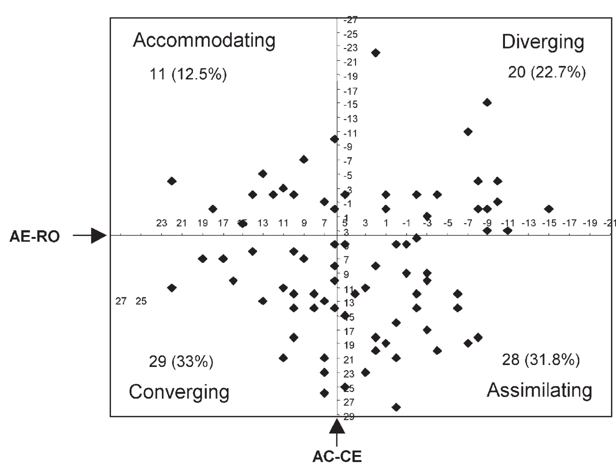

Figure 13. Demirbas and Demirkan's distribution of Learning Styles Types of architecture

students. From “Focus on architectural design process through learning styles,” by O. Demirbas and H. Demirkan, 2003, *Design Studies*, *24*(5), p. 448. Copyright 2003 by Elsevier. Reprinted with permission.

To attempt to answer the question of significance, the author of the present study analyzed Demirbas and Demirkan’s data with chi-square goodness-of-fit tests, and found the group frequencies significantly different, $\chi^2(3, N = 88) = 9.54$, $p = .02$. Follow up pair-wise comparisons confirmed that the proportion of Accommodators was significantly less than Assimilators and Convergers, $\chi^2(1, N = 88) = 7.41$, $p = .01$; and $\chi^2(3, N = 88) = 8.10$, $p = .00$, respectively.

Demirbas and Demirkan used an ANOVA to assess the Learning Style Types’ performance on the four stages of the project. In Stage 1, the written research report, no significant differences were found. The authors attribute this to a “very low” response rate (53.4% incomplete) rendering the results inconclusive. However, they found significant differences between group means for Stages 2 and 3, but not for Stage 4. Post hoc tests revealed that in Stage 2 Accommodators significantly outperformed Assimilators, and also outperformed the other two groups, but not significantly. The authors theorized that:

> The accommodating learners combine the learning steps of AE (learning by doing) and CE (learning by experiencing), they have the ability to learn primarily from ‘hands-on’ experience. Since the product of stage 2 was a drawing exercise and it was just handled after a lecture about the topic, this result sounds logical. (p. 450)

In stage 3, Assimilators significantly outperformed each of the other three groups. The authors considered that:

> Since assimilating learners combine learning steps of RO (learning by reflecting) and AC (learning by thinking), people of this style are more interested in abstract ideas and concepts. The exercise in stage 3 was the construction of a three-dimensional model of the designed staircase... an abstraction of a real staircase... although it was expected that the mean of converging students would be the highest in stage 3, since the converging style is dealing more with abstract conceptstualisation [sic] and active experimentation. (p. 450-451)

All groups showed a significant improvement in performance between Stages 2 and 4, as hypothesized, although Assimilators showed “the highest” improvement, and

Accommodators “the lowest.” But, while Convergers did not show the most improvement they nevertheless had the highest performance in Stage 4 (p. 437, 451).

Kvan and Yunyan (2005) used the LSI 2.0 (Chinese translation) to study two groups of undergraduate architecture students’ performance on design projects. The first group was 37 second-year students who were asked to design a kindergarten in nine weeks (“Program 1”). The second group was 44 third-year students who were asked to design a domestic residence in eight weeks (“Program 2”). Although differing in content, both programs were presented similarly and followed a similar agenda. The performance criterion was each student’s final product, assessed as a weighted, combined score of: oral presentation, concept development, design functionality, and drawing and model presentation. They were evaluated by a jury of teachers and professionals.

Figure 14 depicts the learning style distributions of Kvan and Yunyan’s samples. Both reveal substantial preferences for Diverging and Assimilating styles, and for Reflective Observation rather than Active Experimentation.

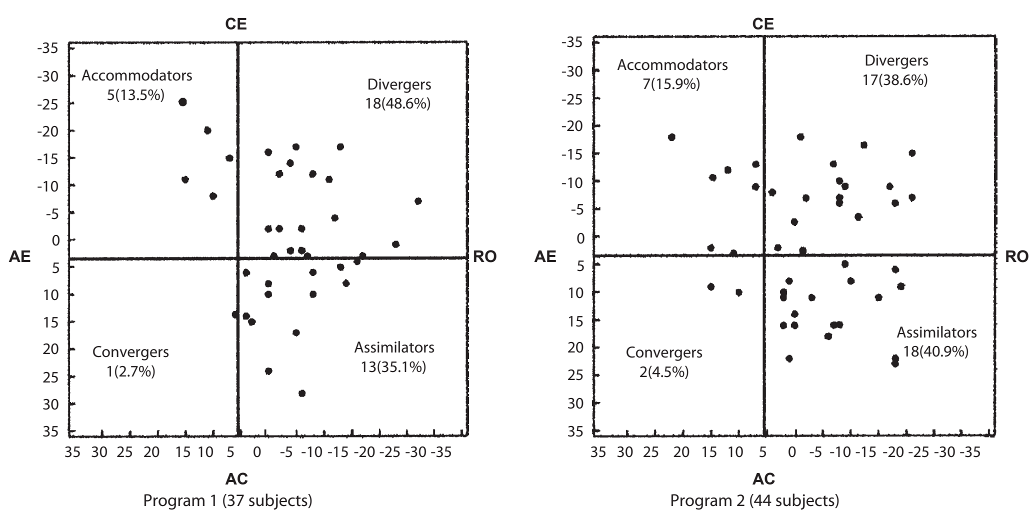

Figure 14. Kvan and Yunyan’s distribution of Learning Styles Types of architecture students. From “Students’ learning styles and their correlation with performance in architectural design studio,” by Kvan & Yunyan, 2005, *Design Studies*, *26*(1), p. 27. Copyright 2005 by Pergamon/Elsevier. Reprinted with permission.

A comparison of Figure 13 and Figure 14 seems to indicate that Demirbas and Demirkan (2003) and Kvan and Yunyan (2005) both used the same split points to determine group frequencies, although it is difficult to ascertain from the presentation (both figures are presented here in the same size and format as they appeared in the original publications). Kvan and Yunyan state that they divided the groups at AC-CE = 3-4 and AE-RO = 5-6.

Kvan and Yunyan noted the similarity with Demirbas and Demirkan (2003)—a preponderance of Assimilators—but also the difference that their sample contained significantly less Convergers. They also noted that their finding was at odds with Kolb and Wolfe (1981) who found Accommodating the predominant style among architects. But, they failed to point out that Kolb and Wolfe's sample was drawn from *practicing professional* architects, not architecture students. However, and consistent with Kvan and Yunyan's finding, Kolb and Kolb (2005a) reported that architecture *students* were predominantly Assimilating. Since ELT proposes that learning styles are shaped by experience, It is logical that the proportion of Accommodators among professional architects might increase over time with experience and professional practice. This is also consistent with Nulty and Barrett's (1996) finding that students' styles shifted as they became more specialized in academic majors.

To assess performance, Kvan and Yunyan transformed their students' final numeric scores into nine grades based on ranges and used "a chi-square analysis" to "test the correlation between the four learning styles and grades" (p. 27). It is not clear exactly what their procedure was, but we have assumed they tested the frequencies of the nine grade categories within the four Style Types with a chi-square goodness-of-fit test. In any case, they reported that they found statistically significant "correlations" in both programs.

Next they *t* tested the mean performance of every pair of Learning Style Types for both programs. Program 1 yielded no significant difference in performance among the Style Types. For Program 2 they found “significant differences between Accommodators and the other three learning styles...and between Divergers and Assimilators” (p. 28). Unfortunately, the authors did not specify these differences, nor did they provide their data to allow independent analysis by others.

Kvan and Yunyan dropped consideration of the Converging Type in Program 1 since it only contained one case, and arguably should have also done so in Program 2 since it only contained two cases. Consequently, the Converging category in Figure 15 should have been omitted, since it has no statistical significance and is distracting. Figure 15 also misrepresents the means by using bar charts, which symbolize categorical quantities, while means should properly be presented as individual points, not quantities.

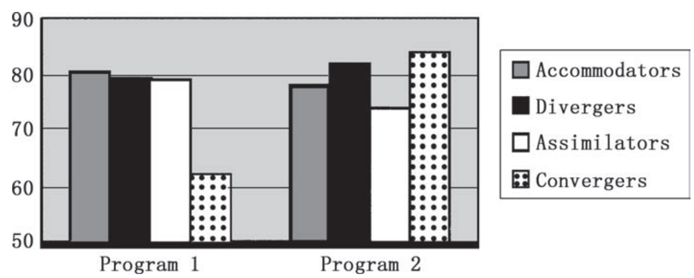

Figure 15. Mean performance scores of architecture students by learning style. From “Students’ learning styles and their correlation with performance in architectural design studio,” by Kvan & Yunyan, 2005, *Design Studies*, *26*(1), p. 27. Copyright 2005 by Pergamon/Elsevier. Reprinted with permission.

Despite these shortcomings, it appears that the difference in performance among the Style Types in Program 2 was attributable to the significantly superior performance of Divergers. Although Convergers appear to have a higher mean performance in Figure 15 it was not significant, and the authors concluded “this may be because of the small sample size for the convergers [i.e. n = 2]” (p. 28).

Demirbas and Demirkan (2007) again used the LSI 3.0 to investigate the relationship between learning style and performance in three successive classes of freshman architecture students (N = 263). The performance criteria were achievement in each of four courses, (a) Basic Design (a design studio course), (b) Technical Drawing and Lettering (a technology-based course), (c) Art and Culture (a fundamentals course) and (d) Drawing (an art course).

Freshman students were selected because this allowed the researchers to assume that design education had not yet affected their learning styles. This assumption was partly based on longitudinal research by Kolb and Kolb (2005b) that found students moved from a reflective to an active orientation on the transforming dimension (AE-RO) as they progressed through years of higher education. Sampling of three successive years by Demirbas and Demirkan was intended to test the stability of the learning style distribution of freshman architecture students across time and cohort in the program at Bilkent University, Ankara, Turkey. No significant differences were found between the three years' distributions. The distribution was concentrated in the Assimilating and Converging styles for the first two classes and Converging for the third, similar to Demirbas and Demirkan (2003). The lowest proportion for all three classes was in Accommodating.

Demirbas and Demirkan noted that their finding was at odds (a) with Kvan and Yunyan (2005) who found a preponderance of Divergers in one group and Assimilators in a second group, (b) with Kolb (1984) who found Accommodating the dominant style of architects, and (c) with Newland, Powell, and Creed, (1987),[12] who found that architecture students generally had a preference for Assimilating.

Demirbas and Demirkan argued that the divergence with Kvan and Yunyan (2005) is consistent with ELT since Kvan and Yunyan's sample was drawn from junior rather than freshmen students. However, the present author again notes that Kolb's (1984) sample were practicing architects, so their styles may not have matched due to

[12] This is an error by Demirbas and Demirkan, the correct attribution is Powell (date unspecified, cited by Newland, et al., 1987, p. 4). Newland, et al. actually surveyed practicing architects and found a relative absence of Assimilators, supporting other findings that the styles of students and professionals are dissimilar.

differences between academic and professional environments, or any number of other unrecognized variables. And also notes that Newland et al. did not report the grade level of their sample, so the influence of that variable is also unknown.

Regarding performance, Demirbas and Demirkan found the scores of Converging students significantly higher than Diverging students in the second and third classes—but only in the Basic Design Course. The authors reasoned that:

> Students who are converger learners are best at finding practical uses for ideas and theories (Hsu, 1999). Smith and Kolb (1996) state that they have the ability to solve problems and good in making decisions in finding solutions to problems. Since design is considered as a problem solving activity, the converger learners are successful in design process. Diverger learners are interested in gathering information (Hsu, 1999), although these learners are more creative compared to the others; they are not systematic in problem solving (p. 357).

Demirkan and Demirbas (2008) (note change in authorship) subsequently reported a similar study of three successive classes of freshman architecture students, this time to investigate factor loadings among the LSI inventory items. Their sample appears to be the same as their 2007 study with an additional 13 participants, though they are not explicit (2007 N = 273; 2008 N = 286). Regardless, the distribution was nearly identical with most students falling in the Assimilating category.

However, the authors observed that the mean scores of the students fell close to the intersection of the vertical and the horizontal axes (AC-CE = 7.44, AE-RO = 5.20, respectively). From this they concluded that “freshman design students have a *balanced* learning style preference by being at a coordinate closer to the intersection of axes compared to the [professional] architects in Kolb and Kolb’s (2005a) study” (p. 262, italics added). This implies that freshmen are less specialized in their preferences, and therefore more balanced, adaptable, and flexible in their approach than either more advanced students or professionals.

Taken together, the studies reviewed in this subsection reported a greater proportion of Assimilators, and second, Divergers in their samples. Adding to the complexity, the Diverging, Assimilating, and Converging groups each outperformed other groups on specific projects, courses, or phases. Somewhat surprisingly, architecture students with an Accommodating style demonstrated significantly superior performance in two studies, despite their smaller proportion in the sample. Interestingly though, the majority of professional architects are Accommodators (Kolb, 2005a), suggesting that the requirements of academia and professional practice are different.

Finally, in addition to the problems presented from using different test versions, ambiguities about split points, and using different statistical analyses, another difficulty arises from the assumption that a particular sample is a random (or representative, or legitimate) sample drawn from the population with which an instrument was standardized and validated. In the present case, the normative scores for the LSI 2 and LSI 3 were based on a sample 1441 people. The norms for the next version, LSI 3.1 (used in the present study), were based on a “larger, more diverse and representative” sample of 6977 people (Kolb & Kolb, 2005a. p. 10). However, 80% were U.S. residents, and 20% from 64 other countries. By way of comparison, Demirbas and Demirkan’s samples were drawn from architecture students in a specific program at Bilkent University in Turkey, using a Turkish translation of the LSI. Kvan and Yunyan’s (2005) study faced similar circumstances, but in China. It seems there is little researchers can do except to acknowledge such limitations, and the unavoidable limits of tools and time, be cautious about generalizations, and move forward. On the other hand, and fortunately, limited studies of purposeful samples are valuable and necessary contributions to the literature regarding an instrument’s external validity.

Learning style and instructional design. ELT views learning styles as semi-stable and adaptive. It predicts that, as individuals specialize within domains and construct useful knowledge, they adopt learning styles best suited to their discipline. This flexibility contrasts with the stable and tenacious character of cognitive style theory. Not surprisingly, Kolb & Kolb (2005a), found that student learning styles differed significantly by academic field, both from propensity and from adaptation.

Figure 16 shows the position of educational specializations within Kolb's Learning Style Type Grid based on the LSI 3.1 normative scores. The major subgroups appear in bold type and the Learning Style Types in grey. It is noteworthy that "art undergraduate" falls in the upper right, Diverging quadrant, and those disciplines whose stock-in-trade is ill-defined problem solving (e.g. architecture, fine arts, social sciences) also congregate on the reflective, right side, represented by the Diverging and Assimilating styles (the position of the present study's VCD sample, which also falls in the Diverging quadrant, has been added to the figure).

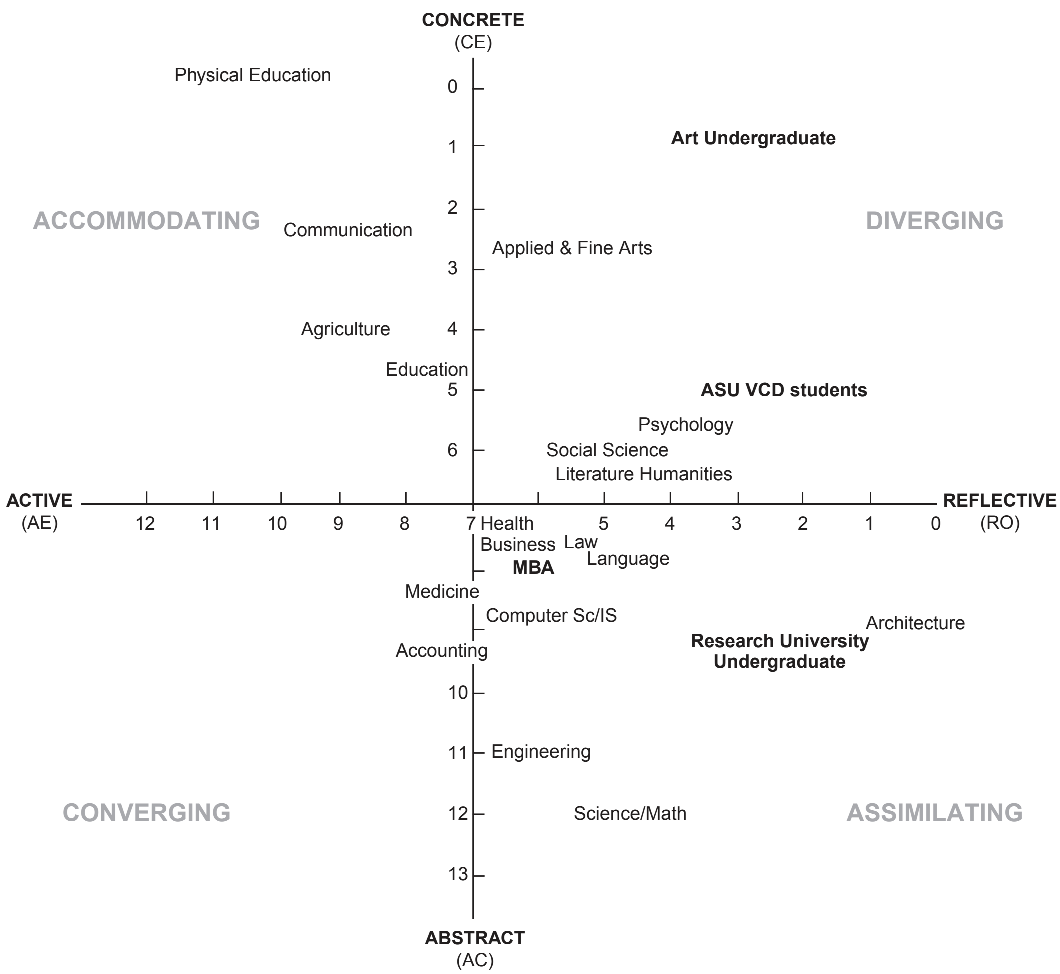

Figure 16. Distribution of learning styles by educational specialization on the Learning

Style Type Grid. Adapted from *The Kolb Learning Style Inventory – Version 3.1: 2005 technical specifications*, by A. Y. Kolb and D. A. Kolb, 2005a, Boston, MA: Hay Resources Direct, p. 27. Copyright 2005 by Experience Based Learning Systems, Inc. Reprinted with permission from Hay Group Inc.

As with cognitive style, some researchers have argued enthusiastically for the matching hypothesis (Bostrom & Lassen, 2006; Demirbas & Demirkan, 2007; Kolb & Kolb, 2005: Kvan & Yunyan, 2005; Sadler-Smith, 1996). And again, there is conflicting evidence and lack of consistent support for the proposition.

Nulty and Barrett (1996) used ELT as the basis for a survey study of 672 undergraduate students. They found that college students in the first third of their studies exhibited similar learning styles regardless of major, but that the learning styles of students in the final third of their studies were more related to the learning requirements of their academic major. Furthermore, students who adopted learning styles that matched their academic major reported more positive educational outcomes. Both of these findings lend credence to ELT's assertion that learning styles are situationally adaptable, and change over time and with experience. So, although this could be construed as evidence in favor of the matching hypothesis, it could equally be an argument against it, since students may adopt any learning style that is rewarded, regardless of their independent preferences. And, in line with this, Nulty and Barrett caution against generalizing from findings about one group of students to all students in a discipline because—aside from the nature of the subject matter—style preferences could be the result of particular instructional design, structure of curriculum, culture, etc.

Demirbas and Demirkan (2003, reviewed above), interpreting their complex results, concluded that because design is a combination of crafts, technologies, and disciplines, it represents all stages of Kolb's ELT model and that "all of the four learning styles occur in the design studio process" (p. 452). Instead of any single style being the ideal for design education, different stages are associated with different styles. instructional design should recognize the range of students' styles, and, in the end, incorporate all phases of the learning cycle.

Kvan and Yunyan (2005, reviewed above) concluded from their findings and their comparison with Demirbas and Demirkan (2003), that design students use all phases of ELT's learning cycle since design is a combination of crafts, technologies, and other disciplines, which call for various approaches to learning. And, that students *without* strong style preferences may be more able to adapt to the diverse demands of ill-defined problem solving in studio-based programs. Learning in a design studio setting "can encompass a wide range of learning styles if its programs start from ill-defined design problems, permit a range of communication media, and are engaged over a relatively long duration, hence allowing more freedom in learning approaches" (p. 32). They suggested that taking an inventory of students' learning styles at an early stage may help teachers tailor teaching to accommodate diverse styles. They also suggested that national culture may influence learning styles and learning environments.

Demirbas and Demirkan (2007, reviewed above) recommended that, in order to continuously improve the quality of learning, departments should conduct systematic reviews of instructional design, and of design-studio projects to ensure that they are inclusive and incorporate all learning styles. They also recommended that teachers discuss learning styles in the classroom and use such discussions as a (metacognitive) tool to focus communication, promote awareness of individual differences, and to highlight the value of different approaches to project work. They further recommended that students be grouped into teams comprised of different Learning Style Types as a working example of the strength of different approaches for specific goals. The authors called for comparable studies in graphic design education and other design programs.

Summary and Conclusion. This section reviewed literature detailing the history and principles of learning style theory and Kolb's ELT, the development and structure of the psychometric instrument used in this study, Kolb's LSI, and studies of learning style in education and design education.

Learning style research in education has been preoccupied with the matching hypothesis. Most studies report complex, conflicting results and conclusions, and attempt to establish external validity. When the components of study variables and methods are identified, isolated, and examined one-by-one, it is clear that some studies inadequately acknowledge, or account for non-comparable differences between:

- versions of instruments,
- specifications for dividing samples into Style Type groups,
- statistical and sampling assumptions and methods,
- students and professionals in a discipline,
- students in different “design” disciplines and programs,
- diverse populations, cultural, and linguistic distinctions.

The LSI has not been shown to have robust external validity, and may not be useful for generalizing to all populations. Kolb and Kolb (2005a) made it clear that the LSI was *not* intended to be a predictive instrument. In addition, when used to study small, purposive samples of “design” students, the findings about preferences and performance are generally inconsistent because of inconsistencies in methodologies. However this is an informative advantage and for the present study. Results from limited samples of different groups are useful for contrasting the various design disciplines, and revealing the characteristics of samples in order to improve instructional design in productive, specific, limited ways.

Generally the authors of studies of learning styles in design education conclude that instructional design should engage all phases of the ELT cycle since design problems embody all phases, and secondarily suggest that students with moderate style preferences have an advantage in being versatile. They encourage educators and instructional designers to use learning style theory as a tool for communication, inclusive presentation, student self-awareness, team building, and as a vehicle for continuous improving the quality of learning.

Cognitive Apprenticeship in Education and VCD Education

The previous chapter reviewed the cognitive apprenticeship approach to learning and instruction. This subsection begins with a review of literature supporting the use of the principles of cognitive apprenticeship in education. Second the review examines those principles in terms of VCD education and offers an example of as exemplified in a course designed by Kelly (2001d). Finally it includes a brief review of similar principles as implemented in ASU's (2008) curriculum. The material reviewed in this subsection is relevant to research question four: *How can the knowledge created in this study be used to improve instructional design for the transitional phase in VCD programs?*

Cognitive apprenticeship in education and instructional design. Collins et al. (1991) offered three examples from other authors of the successful use of cognitive apprenticeship principles in foundational courses in reading, writing, and mathematics. Collins et al. point out that these techniques can be adapted to any age group.

In their first example, Palincsar and Brown's (1984) reciprocal teaching of reading, the teacher modeled expert teaching methods, then used extensive coaching to enable individual students to assume the role of "teacher." This encouraged exploration, reflection, and metacognitive development. The procedure was a form scaffolding, and once individual students became proficient, the teacher faded support. As part of the process students also developed summaries and questions for their presentations. Then students were called on to evaluate the summaries and questions of other students. This pushed them to articulate their understandings of the effectiveness of methodology, and to allow their new knowledge to be "freed from its contextual binding and…be used in many different contexts" (p. 6).

In the second example, Scardamalia and Bereiter's (1985) procedural facilitation of writing, the authors broke down the writing process into a series of discreet steps, or planning processes. These steps were created by examining and contrasting the methods of expert writers to those of novices to identify differences and successful tactics. To put these to practical use Scardamalia and Bereiter developed a list of prompts that students could refer to when planning and writing. The students used cue cards to remind them of the prompts when they attempted to construct their own essays. This method also involved the combination of modeling, coaching, scaffolding, and fading to achieve goals similar to those of Palincsar and Brown's reciprocal teaching. As in the previous example, students evaluated and discussed each other's progress, and incrementally assumed the role of teacher as scaffolding from the teacher was faded.

Collins et al.'s third example was Schoenfeld's (1983, 1985) method for teaching mathematical problem solving. Like the two previous examples, Schoenfeld's method involved the principles of modeling, coaching, scaffolding, and fading that encouraged exploration and reflection on problem-solving processes. But, his approach placed a greater emphasis on heuristics and control strategies for generating and evaluating alternative courses of action that lead to successful solutions, given the particulars of specific problems.

As a class, students examined the specifics of successful problem-solving paths and then conducted "postmortem analyses" on how those evolved. Two "breakthroughs" become apparent from this process. The first resulted from examining a series of straightforward examples that were easy to calculate to see if a pattern emerged. Then looking at those examples to see if a general pattern emerged for solving more complex problems. The second breakthrough involved pausing to reflect on whether the resulting solution-path was appropriate for the conditions and requirements of the original problem. Was it messy or elegant? This again hinged on modeling by the teacher, small-group problem-solving sessions, and collaborative efforts among students, to promote a constructive learning environment.

In addition to the reviews furnished above by Collins et al. (1991), Graves and Fitzgerald (2003) cited 16 studies that addressed scaffolding from various perspectives, and noted, “Since its introduction 25 years ago, the concept of instructional scaffolding has been investigated, elaborated, related to other instructional concepts, and strongly endorsed by a host of educators” (p. 98).

In one such study, Atkinson, Renkl, and Merrill (2003) reported improved performance on a learning task when scaffolding-based instructional methods were combined in two experiments. The participants were 78 undergraduate students (Experiment 1), and 40 high-school students (Experiment 2). The criterion was performance on solving word-problems about probability. The authors tested the effectiveness of presenting subjects with: (a) problem-solving examples paired with practice problems, then combined those with, (b) prompts that encouraged the learners to self-explain the principle behind each worked-out step of the solution, and finally, (c) fading (i.e. systematically removing) elements of the solutions presented in “(a)” above.

Atkinson, et al. found that the addition of the self-explanation prompts significantly improved performance on both the *near-transfer* (solving similarly structured problems) and *far-transfer* (solving differently structured problems) of new knowledge. That finding appears to support Vygotsky’s and Piaget’s concept of decontextualization, scaffolding, and also the use of metacognitive strategies. The authors concluded that their findings:

> support the basic tenets of...the cognitive apprenticeship approach (Collins, Brown, & Newman, 1989). This approach is characteristic of Vygotsky’s (1978) “zone of proximal development” in which problems or tasks are provided to learners that are slightly more challenging than they can handle on their own. Instead of solving the problems or tasks independently, the learners must rely—at least initially—on the assistance of their more capable peers and/or instructors to succeed. According to this approach, the learners will eventually make a smooth transition from relying on modeling to scaffolded problem solving to independent problem solving.

The following subsection reviews the use of cognitive apprenticeship principles in VCD education and provides an example of how those methods could be useful during the Transitional Phase.

Cognitive apprenticeship in VCD education. Although the Bauhaus/ Swiss model epitomizes most prominent VCD programs in the US, surprisingly little literature specifically addresses the Transitional Phase. The notion of bridging students' experiences from theoretical to applied exercises is frequently touched upon, but few authors discuss the process in practical or empirical detail. What is clear from the informal commentary of educators and students, however, is that the Transitional Phase represents a "great leap forward" for many, and that finding effective ways to facilitate development in this transition results in tangible consequences for persistence, and ultimately, academic and professional success.

The cognitive apprenticeship approach provides an adaptable model of instruction with many parallels to the structure of traditional design education as exemplified by the Bauhaus and Swiss schools. And, as previously noted, its formal terminology provides a unambiguous framework for concrete discussions, and for identifying specific methods.

Becker (2005) alluded to the principles of cognitive apprenticeship without using the formal terms:

> The problem with the way most of us have been teaching is that *design reasoning, thinking, and decision making are not revealed to the student as these processes are happening*. 'I would try this because…(that's a better face to use in this situation. It references…that color is a bit harsh; it doesn't speak to the audience you are trying to address…)' This running commentary is a missed, but essential, part of design pedagogy. Thinking out loud represents a moment that brings experience to the forefront. It slows down the reflective process, which, due to technology, has sped up as it collided with and was overtaken by the production process. The comments are heard only after something is printed and shown. Students have already gone away, made questionable design decisions, and committed them to paper. The instructor then offers a critique that they may or may not hear because by now, their guard is up. Isn't a critique actually just telling someone that something that has sprung from his head is not yet quite right? And we expect students to welcome a critique of their personal expression

> (which is distinctly unlike arriving at the wrong answer in an algebraic equation)! The problem with the critique is that it requires a suspension of the self. On the other hand, if the faculty member makes sure that students have been brought along *inside* the process, they tacitly absorb the thinking, reasoning, and intuiting that result in smart design decisions. They are not defending a poor *fait accompli*. (p. 56)

Kelly's (2001d) **Mini-Course in Visual Communication*.*** The remainder of this subsection examines Kelly's (2001d) *Mini-Course in Visual Communication* as an example of a successful learning program in VCD education that exemplifies many principles of the cognitive apprenticeship approach.

Kelly (2001b) observed:

> All students do not learn in the same way nor at the same rate. Some learn from success, others from failure. Learning may be erratic. For many students, learning is the cumulative effect of all course work; while for others, the learning is centered in one or two problems. For some students, understanding might not come until much later.…All students learn from a combination of methods.

And:

> It was not until later in my teaching career that I became aware that students who executed well on a particular assignment seldom carried over the experience of doing that problem to the next one. (p. 81).

In this, Kelly identified differences in cognitive and learning style among students, and understood that these differences influenced the process, progress, comfort, and pace of learning. This is particularly evident in the gap students exhibit in connecting visual aesthetics with communication during the Transitional Phase.

In response, he began constructing his *Mini-Course in Visual Communication* at the Minneapolis School of Art in 1958 (Kelly, 2001d). His goal was to develop a method for simultaneously balancing perceptual and conceptual development through sequential problems. He noted "There is strong evidence that what students do in [the *Mini-Course in*] *Visual Communications* applies to upper level problems and work following graduation" (Kelly 2001d, p. 212).

Since a primary purpose of VCD is to translate intangible concepts into visual form using color, shape, line, etc., the exercises stressed conceptual development using the formal, perceptual elements as the medium. Kelly intended to teach students "direct" as opposed to "indirect" visual communication. He explained:

> to communicate *cold*, you would use colors, shapes and line qualities that reflect the meaning of the word. The image generally is abstract. Indirect communication of *cold* might be representation of an ice cube or a human figure with wavy lines around it. To read the communication, you first would have to know what an ice cube was, or that wavy lines are a symbol for shivering which suggests cold. (ibid., p. 211)

The problems presented in the course contained four learning objectives: (a) communication through visual images, (b) formal values connected with composition, shapes, and color, (c) hand skills, and (d) learning the design process and how to make refinements (ibid.). There were three main criteria for evaluation: (a) the quality and clarity of the concept and the communication, (b) the formal values and aesthetics of the image, and (c) craftsmanship.

The course was dovetailed into the Basic Design course of the first year in one-hour weekly critiques and assignment sessions. Early problems were simple and structured then graduated in complexity, difficulty, and freedom.[13] As noted above, the structure of Kelly's course can be interpreted as a tacit adaptation of the four dimensions advocated by Collins et al.'s (1991) cognitive apprenticeship framework: (a) content, (b) method, (c) sequencing, and (d) sociology.

On CA's content dimension, domain knowledge was promoted by having students work with cut and torn paper (hand skills) and methodical experimentation with design solutions (visual communication, design process). On the method dimension, modeling was accomplished through physical demonstration, and by periodically showing and discussing professional work that used strong communication concepts in class. Limiting the examples of final solutions was important as it kept students from becoming formulaic and imitative in their own solutions, and drove them to do the

[13] Examples of solutions are available at: http://www.rit.edu/library/archives/rkelly/html/04_cou/cou_vis3.html and the pages that follow.

exploration required for understanding the problem-solving process. Students were also limited to worked independently outside of class, rather than in groups, because of the same tendency to “borrow” from other students. This placed a limitation on CA’s sociological principle of cooperation, but these restrictions were relaxed as the concepts of abstract communication and independent work were recognized. Gradually the principles of cooperation, community of practice, and situated learning became more and more important as students progressed through the increasingly complex assignments.

Coaching, scaffolding, and fading were conducted continuously on an individual basis between teacher and student; hints and suggestions were provided, but were usually general and indirect in order to encourage autonomous skills of exploration and metacognition. The weekly in-class group critiques also contributed, as students heard and (hopefully) internalized the comments of the teacher, and of other students. The function of the weekly group critiques also fulfilled the methodical goals of articulation and reflection. In addition reflection was sustained by encouraging students to redo work repeatedly until their performance was acceptable, or until they reached the end of the semester. This method is also is consistent with “replaying” solution-paths as a means to reflect on which strategies were more or less successful.

The sequencing principles of global before local skills and increasing diversity were addressed by limiting early assignments to simple, abstract interpretations of single words or concepts (e.g. “hot,” “cold,” “pain”) and limiting the use of color and shape. This led to assignments requiring more complex communication, composition, and color. The latter included multiple verbal and conceptual elements and greater freedom of choice (e.g. designs representing the function of a tool, a scientific principle, or a travel poster). This sequence also pushed students to continually develop and reassess their conceptual models, because students were not creating an imitative example of a final product, as in traditional apprenticeship, but developing problem-solving skills that led to a succession of unique solutions. In other words, students came to the course with some basic formal skills and understandings, and their conceptual models evolved as the complexity of the assignments increased, and as students developed higher-level cognitive and metacognitive skills. Conceptual modeling was also enhanced through observation of demonstrations, and the slides of expert solutions.

Finally, a crucial part of the method that supported all aspects of the learning program and the principles discussed above was the keeping of “progress books.” For each project, students were required to keep notes, sketches, copies of work in progress, research materials, etc., and bind them into an organized book that was presented at the conclusion of the semester. These were particularly helpful in the early stages since they revealed to students the improvement and development they had achieved: “Learning became tangible, and students reacted with a sense of accomplishment, greater commitment and increased productivity” (Kelly, 2001b, p. 90). The progress books served a similar purpose at higher levels in the program and were also were valuable as a documentary asset for graduates so applicants could document and explain their design thinking to interviewers.

Cognitive apprenticeship approaches at ASU. As of 2008, the instructional design of ASU’s VCD program included projects, and a variety of strategies that were consistent with the principles and methods of cognitive apprenticeship reviewed above. Among the examples of such projects are the *Message design – Visual comparison project,* and other projects described in “METHODOLOGY,” p. 95. Tactical devices that presented information in various ways, to accommodate various cognitive and learning styles include the structured use of quizzes and texts, group brainstorming sessions and critiques, and presentations to the Junior class by Senior level students about internships and professional experiences. These latter support the transition to professional practice, and prepare Junior-level students for internships and the social context of professional design studios.

Findings and Opportunities

Opportunities

Our literature review revealed the following opportunities for research:

- A limited amount of study and literature that focused on the Transitional Phase of VCD education,
- Lack of studies of predictors of performance in the Transition Phase of VCD education,
- Lack of studies of cognitive style and learning style in VCD education,
- Lack of comparative studies of cognitive style and learning style in VCD education and other design disciplines,
- Lack of formal theoretical models of instructional design in VCD education

Research Questions

Based on these opportunities the following research questions were developed:

1. Performance. What is the relationship between VCD students' prior academic performance, cognitive style, and learning style, and their performance in the Transitional Phase?
2. Preferences. What Cognitive Style Type and Learning Style Type do VCD students prefer compared to other groups?
3. Application. How can the knowledge created in this study be used to improve instructional design for the Transitional Phase in VCD programs?

3 METHODOLOGY

Introduction

This chapter describes the methodology used to generate, document, and organize the data required for this study. Topics include: the participants and sample selection, the study variables, methods of data collection and research instruments, methods of data organization and analysis, and procedure for documenting and organizing the results.

This study was exploratory. In order to address the research questions, several approaches to analysis were used in a general-to-specific program proceeding from a broad-based examination to a finer-grained analysis of subsets of data. It was also necessary to contrast the characteristics of this study's participants with those in analogous studies. The statistical procedures used in this study included correlation, multiple linear regression, ANOVA, chi-square, *t*-tests, and various follow-ups and tests of assumptions. These approaches are based on a variety of approaches used by Atkinson (1998), Demirbas and Demirkan (2003, 2007), Ford, Eaglestone, Madden, and Whittle (2009), Grimley and Banner (2008), Garavalia and Gredler (2002), Kvan and Yunyan (2005), Roberts (2006, 2007), and Yukhina (2007).

Participants and Sample Selection

The study participants were drawn from a class of 40 first-semester, third-year VCD students at ASU. Three subjects were eliminated because of missing data, leaving a final sample of 37 (26 female, 11 male; ages 22 to 40), or 92.5% of the total fall 2006 third-year class.

Because of the exploratory nature and limitations of this study, it was neither possible, nor desirable to obtain a random sample drawn from the entire population of undergraduate students in all VCD programs. In fact, the sample does not constitute a strictly random sample of students who have attended the ASU VCD program over its history. However, the researchers judged it to constitute a sample that reasonably represented students in ASU's program for purposes of exploratory study. This is based on the fact that ASU's VCD program has historically maintained a consistent standard for entry to the program, stability of its curriculum and structure, and continuity of faculty and facilities.

Robson (1993) described this method as *purposive nonprobability* sampling. The sample was "purposive" in the sense that it typified a category of interest to the research, and "nonprobable" in that it was not randomly drawn from a larger population. The authors of the present study followed Tongco's (2007) advice that "[when] analyzing data and interpreting results, remember that purposive sampling is an inherently biased method. Document the bias. Do not apply interpretations beyond the sampled population" (p.151). Atkinson (1998) used an analogous method, reviewed in "Academic performance," p. 61.

Human Subject Research Requirements

The study protocol satisfied the conditions for exemption from human subjects research requirements pursuant to Federal regulations, 45 CFR Part 46.101(b)(1), and the study was granted this exemption by ASU's Institutional Research Board – Research Compliance Office on April 18, 2007.

Each subject signed a detailed consent form authorizing the researchers to collect and analyze their academic data, results of psychometric tests, and, if the subject chose to participate, interview data. The consent form also provided a description of the study, the potential risks and benefits, anonymity procedures, and payment for participation. Each subject was paid $10 for his of her participation (see APPENDIX G, p. 175, for documentation).

Anonymity. Participants chose, and were identified by anonymous nicknames. The researchers maintained subject anonymity by dividing data gathering and sharing.

The principal investigator was responsible for compiling data for the dependent variable; the coinvestigator was responsible for compiling and analyzing data for the independent variables. Out of necessity, the principal investigator maintained a list that matched participants' nicknames with real names in order to furnish the dependent variable data, identified by nickname, to the coinvestigator. After the study was complete the list was destroyed. Using this double-blind protocol, neither investigator had access to both the full data set and participants' identities.

Study Variables

Introduction to Study Variables

This subsection describes the independent and dependent variables studied and how they were handled. The following variables were identified for study based on the research questions identified in "Findings and Opportunities," p. 95, and summarized in Table 3, below. Each of these is a composite of several related constituents, summarized in the following list:

Independent (or predictor) variables:

- prior academic performance:
    - prior Cumulative college GPA ("cumulative GPA"),
    - VCD course GPA ("design GPA"),
    - cumulative college GPA without VCD design course GPA ("cumulative minus design GPA")
- learning style:
    - primary dimensions
    - Learning Style Types
- cognitive style:
    - primary dimensions
    - Cognitive Style Types

Dependent (or criterion) variable:

- performance on Transitional Phase studio design projects ("Transitional Projects").

Table 3 summarizes the structure of the data analysis, and restates the research questions for reference.

Table 3

Research Questions and Analytic Methods.

Research Questions:

1. What is the relationship between VCD students' prior academic performance, cognitive style, or learning style, and their performance on transitional projects?
2. What cognitive style and learning style do VCD students prefer compared to other groups?
3. How can the knowledge created in this study be used to improve instructional design for the Transitional Phase in VCD programs?

Research Question	Independent Variables	Method	Refinement / follow-up
1	All	Correlation	
1	All	Multiple linear regression	Block, and stepwise entry
1	Prior Academic Performance	ANOVA	Post hoc tests / Bonferroni
1	Cognitive Style, Learning Style	▪ sample split on medians ▪ *t* tests: ▪ 2 primary dimensions ▪ 4 Style Types	Pair-wise *t* tests of performance within VCD sample
2	Cognitive Style, Learning Style	▪ *t* tests: ▪ 2 primary dimensions	*t* tests of means on primary dimensions to other samples
3	All	Evaluation of findings in terms of learning style theory and cognitive apprenticeship	

Independent Variables

The data collected for this study were quantitative, but the cognitive and learning style variables were also treated as categorical as required by theory and statistics. Since there were three independent variables and one dependent variable, conventional choices for analysis were (a) correlation, (b) multiple linear regression, and/or (c) one-way analysis of variance (ANOVA). The latter two methods yield analogous results, but may be more or less appropriate depending upon how research questions are posed and upon the structure of the data. Multiple linear regression has a more "predictive" orientation than ANOVA and therefore was a logical choice, particularly for examining the prior academic performance variables, since those variables did not need to be divided into smaller subgroups, or factors, for comparisons. Also, ANOVA requires an equal number of cases in each cell formed by the intersection of independent variables—regression is more lenient in this regard. Regression is also more tolerant of correlation among the IVs, and thus is more suited for non-experimental data (Coladarci, Cobb, Minium, & Clarke, 2004; Garson, 2008; Green, 1991; Hamburg, 1987).

Although the above sounds fairly straightforward, features of the cognitive style and learning style models, and sample size, required a more elaborate approach involving additional methods such as *t* tests and chi-square tests. These matters are discussed in the following subsections.

Split points, factors, and cell sizes. The cognitive and learning style variables used in this study each consist of two dimensions whose joint scores result in four bivariate style type groups. The scores on each dimension are calculated as a ratio (for cognitive style), or a difference (for learning style), of each subject's scores on test items representing the poles of those dimensions.

As an initial step, Peterson et al. (2003b) recommended independently analyzing the ratio scores on each primary dimension to make internal and external comparisons on just those dimensions. As a second step, Riding (1998) advised researchers to allocate Cognitive Style Types to their study sample in two ways: (a) divide the sample into three groups on each dimension using the sample's median scores (e.g. Holist, Intermediate, Analytic), or (b) use the split points established by a large normative sample.

This gave rise to several concerns. First, the disposition of the present study's data suggested that the latter method would result in unequal Style Type groups and preclude a meaningful analysis. A chi-square goodness of fit test revealed that there were significant differences between group frequencies for both Cognitive Style Types, $\chi^2(3, N = 37) = 8.73$, $p = .03$; and Learning Style Types, $\chi^2(3, N = 37) = 8.08$, $p = .04$. Although this yielded insights, it was likely that such a split would lead to difficulties in subsequent analyses. So, split points based on the median scores within the sample of 37 as in (a) above were used. The results of chi-square tests revealed no significant differences between group frequencies for either Cognitive Style Types or Learning Style Types when using the median split points.

The only other deviation from Riding's suggested methodology was that the Style Types were divided into four (2 x 2), rather than nine (3 x 3) groups in view of the small sample size. These methods are consistent with those used in analogous studies (Atkinson, 1998; Demirbas & Demirkan, 2003, 2007; Demirkan & Demirbas, 2008; Ford, et al., 2009; Kvan & Yunyan, 2005; Nulty & Barrett, 1996; Riding, 1997; Roberts, 2006, 2007). Tables displaying the values of these split points and the resulting group frequencies appear in APPENDIX A, p. 155.

Second, the present study's research questions called for comparisons between its sample and samples from analogous studies. Several of those analogous studies used normative split points established by the particular instruments used in order to establish Style Type group frequencies. The resulting frequencies were then ostensibly used for making *internal* judgments about those studies' samples. However, finding a particular number of subjects in a particular Style Type group based on normative split points in actuality *is a comparison to an external sample*, rather than an internal comparison. Just as dividing one's sample by split points used by *any* other study and then testing group frequencies is an external comparison. It will also be recalled from the "REVIEW OF LITERATURE," particularly the studies reviewed in "Learning Style Research in Design Education," p. 74, that using group frequencies based on normative split points potentially invalidated between-study comparisons because it was unclear whether several studies used identical split points.

Therefore, the present study used *t* tests of samples' mean scores on each of the primary dimensions of style for comparisons to external samples, following the methodology of Roberts (2007). This provided a consistent and unspeculative metric of measurement and comparison, with the important caveat that several studies did not use the same version of the same instrument.

Third, splitting the present study's sample using its medians, as above, then using factors (as required by ANOVA, discussed below), fragmented the already small sample into smaller and unequal cross-group cell sizes. Explicitly, the sample size was 37; therefore the resulting 4 X 4 table of cells for the Cognitive and Learning Style Types would hypothetically contain 37 ÷ 16 = 2.3 cases per cell—assuming that all group frequencies were exactly equal. This meant that the resulting *F* and *p* values would be imprecise, because the sample was too small for sufficient statistical power for full factorial analysis given the number of IVs (Garson, 2008; Hill & Lewicki, 2007).

As an alternative, the present study used *t* tests. This also has limitations. Although independent sample *t* tests are frequently used to compare group means within a sample (even though individuals are not randomly assigned), the procedure does not provide a way to control for unmeasured variables. That opens the possibility that other variables in the sample may mask or enhance any apparent significant difference in means. Therefore, results should be interpreted with caution (Garson, 2008). Random sampling would control for this, as would the mechanics of regression or ANOVA with a large, random sample. In the present case it was felt that the potential of unmeasured variables was controlled for by the uniformity of the students' experience within the VCD program, and the fact that the IVs were self-generated and based on individual preferences and performance (unlike, for example, a variable such as gender). Tactics for addressing this in future research through alternatives of study design, and statistical and data acquisition methods, appear in the "DISCUSSION," p. 129.

Prior academic performance. Academic performance is a requirement for admission to ASU, and for continuance in the upper level of the VCD program. As such, its consequences were essential to exploring the research questions.

Data collection and procedure. The author placed a request through ASU's College of Design and Registrar's Office for the records on June 22, 2007, was subsequently granted permission, and obtained the requested academic transcripts from the Registrar's Office. Permission for this request was approved through Arizona State University's Institutional Review Board (see APPENDIX G, p. 176).

Cumulative GPA for each participant was obtained directly from his or her transcript. VCD studio course GPA was calculated from the transcripts by segregating and averaging VCD studio course scores. Finally the credit-hour weighted Design GPA was subtracted from the credit-hour weighted Cumulative GPA resulting in the Cumulative minus Design GPA variable.

Anonymity was maintained in compliance with the procedures described above. Scores were organized and recorded under each participant's anonymous nickname in a Microsoft Excel spreadsheet, then transferred to IBM Predictive Analytics Software (PASW, formerly SPSS) for coding and statistical analysis in conjunction with the other variables.

The researcher wished to include comparisons between the VCD student data and related data, such as those from other design programs at ASU, and overall performance of ASU students. However, these were not available from the ASU Office of Institutional Analysis (http://uoia.asu.edu/), or from the US Department of Education Institute of Educational Sciences (http://nces.ed.gov/). In any case, such comparisons, or those with VCD programs at other institutions, were likely to have been misleading since they could not be controlled for grading standards and practices from one program to another. SAT and ACT scores were also precluded from consideration due to missing data in some transcripts.

Data analysis. The data were treated as conventional four-point continuous scale variables and analyzed with ANOVA and regression as detailed in "RESULTS," p. 113.

Cognitive style. Hudson (1966), Roberts (2006, 2007), Yukhina (2007), and others found that cognitive style preferences were associated with student performance in design and other academic programs. Based on their findings and recommendations, this study investigated similar implications for a VCD program.

Instrument. This study used Peterson's CSA to assess cognitive style preferences (see "Development, architecture, and methodology of cognitive style instruments," p. 43). The test generates four kinds of reports with various levels of detail. The most important results of concern to this study were students' Holist-Analytic ratio and Verbal-Imagery ratio. These numeric values represent each participant's position on the two dimensions of Riding and Cheema's cognitive style model. An individual's Cognitive Style Type is determined by the quadrant he or she falls in, as determined by their joint score on the Verbal-Imagery and Holist-Analytic dimensions, as shown in Figure 8, p. 42 .

License. The coinvestigator contacted the author, Dr. Elizabeth Peterson (University of Auckland, NZ), on March 15, 2007, for permission to use the instrument in the present study. The intellectual property rights holder, the University of Edinburgh, UK, subsequently granted a license for its use on March 27, 2007 (see APPENDIX H, p. 179).

Data collection and procedure. All procedural requirements for the administration of Peterson's CSA were observed per the *Verbal Imagery Cognitive Styles Test and Extended Cognitive Styles Analysis-Wholistic Analytic Test administration guide* (Peterson, 2003 - 2005). The coinvestigator read the prescribed instructions to each participant who then took the test individually in a quiet room with the coinvestigator present as an inconspicuous observer. The VICS test took about 25 to 30 minutes to complete, and the Extended CSA-WA test took about 15 minutes.

The test results for all participants were retrieved from the computer-generated report under their nickname, recorded in an Excel spreadsheet, and then transferred to PASW software for statistical analysis.

Data analysis. To address research questions 1 and 2 (see Table 3, p.98), the researchers initially analyzed the CSA ratios on each main dimension (Holist-Analytic, Verbal-Imagery) using methods 1 and 2 below. Then the cases were allocated to the four Cognitive Style Types and analyzed as in 3 below:

1. The mean scores on the two dimensions were compared with respect to the transitional projects variable using independent samples *t* tests.
2. Cognitive Style Types were allocated using the sample's medians as split points, and compared with respect to the transitional projects variable using independent samples *t* tests.
3. The mean scores on the two dimensions were compared to four other samples using single sample *t* tests.

Learning style. Demirbas and Demirkan (2003, 2007), Demirkan and Demirbas (2008), Kvan and Yunyan (2005), Nulty and Barrett (1996), Sadler-Smith (1996), and others found that learning style preferences were associated with student performance in design and other academic programs. Based on their findings and recommendations, the present study investigated similar implications for a VCD program.

Instrument. This study used Kolb's LSI version 3.1 to assess learning style preferences (see "Development, architecture, and methodology of Kolb's LSI" p. 52). The inventory's results are calculated with a scoring key, and scores on the two dimensions of the ELT model—AC-CE and AE-RO—are obtained by subtracting a participant's CE score from the AC score, and the RO score from the AE score, respectively. An individual's Learning Style Type is determined by the quadrant he or she falls in, as determined by their joint score on the AC-CE and AE-RO dimensions, as shown in Figure 11, p. 51.

License. The researchers applied for permission to use the LSI through the Hay Group® (www.haygroup.com), the official distributor of the LSI, in March of 2007. They were granted permission and sent electronic copies of the LSI and the scoring key on March 15, 2007. The terms of the use agreement preclude reproduction of the LSI here, but other documentation appears in APPENDIX H, p. 179.

Data collection and procedure. All procedural requirements for the administration of the LSI were observed per the instructions in the letter of approval and those printed on the inventory itself. The instructions on the inventory tell the test-taker how to fill out the 12 sentence-completion items and to be sure to complete all items. The test was administered in the classroom; the coinvestigator read the printed instructions aloud to ensure that they were understood, and that there were no questions about completing the inventory. The 37 participants completed the questionnaire under their nicknames in about 15 minutes, and the coinvestigator retrieved all copies. Two subjects failed to complete all items, were contacted via the anonymity protocol of this study, and subsequently provided completed copies to the investigators.

The completed questionnaires were scored by hand using the supplied key, the results recorded by nickname in an Excel spreadsheet, organized, and then transferred to PASW for statistical analysis

Data analysis. To address research questions 1, 2, and 3 (see Table 3, p. 98), the researchers initially analyzed the LSI scores on each main dimension (AC-CE, AE-RO) using methods 1 and 2 below. Then the cases were allocated to the four Learning Style Types and analyzed as in 3 and 4 below:

1. The mean scores on the two dimensions were compared with respect to the transitional projects variable using independent samples *t* tests.
2. Learning Style Types were allocated using the sample's medians as split points, and compared with respect to the transitional projects variable using independent samples *t* tests.
3. The mean scores on the two dimensions were compared to four other samples using single sample *t* tests.

Dependent Variable

This section describes the elements that comprise the dependent variable, how data were collected, and how the variable was calculated.

Performance on Transitional Phase projects. The dependent variable data in this study were students' performance on six information design projects during the Transitional Phase semester in ASU's VCD program (Fall semester, 2006, in this case). Other elements that contributed to the final course score that semester such as bookbinding projects, attendance, and quizzes, etc., were omitted since they had no bearing on the research questions.

Review and evaluation procedure. Evaluation and scoring was conducted on a single day at the end of the transitional semester. Groups of eight students set up their semester's work in the reviewing room and exited. The primary investigator, coinvestigator, and two other faculty members reviewed, discussed, and scored all work, and then interviewed each student. In some cases scores were adjusted based on the interviews. The process was repeated sequentially until all work had been evaluated.

Data collection and procedure. Each faculty member recorded a score for each part of each project for each student. These scores were then combined and averaged by one of the senior faculty members, resulting in single composite score for each part of each project for each student. The evaluation score sheet is prohibited from publication due to the anymonity protocol approved for this study.

In compliance with the anonymity protocol of the study, participants' nicknames were substituted for real names before the coinvestigator was given a copy of the final scores. Scores for the six projects were then recorded by nickname in an Excel spreadsheet, organized, and transferred to PASW for statistical analysis.

Statistical analysis. Data for the dependent variable were treated as a continuous scale variable and analyzed with the methods detailed above and in the "RESULTS," p. 113.

Projects. The educational goals of all of the Transitional Projects were: (a) the application of previously learned design fundamentals to information communication design, (b) the development of systematic problem solving skills, (c) an introduction to research methods, and (d) an introduction to working in teams. Five projects had due dates upon which students presented their work at an in-class group critique; the Folded Box Diagram project had a "floating" deadline. However, students were encouraged and allowed to continue refining all projects until the final review. Students received advice on their work from three faculty members on a regular basis throughout the semester.

Project 1: OTC packaging

Application: Over-the-counter labeling and packaging

Description: An applied package design project based on revised government labeling requirements for products containing acetaminophen. Students developed complete retail package solutions for over-the-counter (OTC) pain relief products.

Procedure: (a) Students completed a supplied questionnaire about OTC products, formed teams, and conducted short-term ethnographic/observational research studies of customers interacting with OTC packaging in stores; (b) students returned to the studio and developed concepts and sketches for packaging design based on their observations. Considerations included size, choice of colors, typography, legibility, brand identification, etc; (c) the students produced functional, realistic prototypes of packaging that were later presented at a conference.

Timeline: Two weeks

Project 2: Patent project

Application: Quantitative information visualization and design; visual presentation of multiple sets of quantitative statistical data

Description: (a) Design and production of a one-page printed display incorporating a minimum of three sets of statistical data from different sources, and (b) design and production of an interactive, electronic version based on the printed piece, using Adobe Flash, Microsoft PowerPoint, or other software.

Procedure: The first source of statistical data, patents granted to Phoenix, AZ residents between 1975 and 2005, was supplied to students. Students chose one set of data from this source and provided the second and third sets from their own research. The three sets were then related in a unified visual presentation.

Timeline: 3 weeks

Project 3: Values postcards

Application: Quantitative and qualitative information visualization and design; visual presentation of multiple sets of comparative data

Description. Design and production of a postcard series that compared social values among pairs of countries (7 cards at 5” x 8” trim size); the hypothetical audience was students in foreign design schools.

Procedure. Students were provided two lists of countries and instructed to choose two countries from the first list, and five countries from the second list. The first list contained the United States, Japan, Australia, Pakistan, Israel, Saudi Arabia, France, India, and Poland. The second list: Iran, North Korea, Mexico, Brazil, Argentina, Columbia, China, Iraq, Russia, Afghanistan, and Syria. Students chose a quantitative or qualitative social value, such as number of children per couple, age of marriage, theater attendance, or preferred type of music, etc., then designed a series of individual cards that compared pairs of countries on a quantitative feature of their chosen qualitative value.

Faculty encouraged students to write supporting text as appropriate, and students could include numbers, such as percentages, as annotations to the visual elements. But the presentation had to effectively represent quantities or values visually without the help of verbal or numerical information—in other words, a table containing numbers was not an acceptable solution. The postcards also had to comply with USPS specifications for international mail.

Timeline. 3 weeks

Project 4: Folded box diagram

Application: Diagrammatic display of procedural information (nonverbal, non-quantitative)

Description: Design and production of a diagram of steps for making a folded paper box and lid.

Procedure: (a) Students created a folded box and lid using two square sheets of paper. They devised the procedure themselves, but were told that the sheet for the lid should be one quarter inch larger than the other for a proper fit. (b) Based on their procedure, students designed a sequence of diagrams. The presentation had to be instructional and easy to follow without verbal cues or information. Consistency of scale, appropriate use of color and line, and overall effectiveness of presentation were among the evaluation criteria.

Timeline: Periodic, due at the end of the semester

Project 5: Message design – Visual comparison project

This was the most complex and demanding project, an exercise in progressive message-development and decision-making about visual elements: their meanings, implications, and interactions.

Application: (a) Qualitative information visualization and design; (b) systems design: posters, packaging, publications, brand identity, and design for marketing; (c) repurposing communications for multiple applications; (d) sequential problem solving

Description: Poster design, package design, and brochure design based on a common theme

Deliverables: (a) poster (10” x 15”), (b) 1 large package (5” cube), (c) 6 small packages (2.5” cubes), and (d) brochure

Procedure: Elements were researched, chosen, and added in a prescribed order to create a unified, composite communication. Then, the theme established in the first application was repurposed to several formats. The addition of each element limited or focused the overall message in some way. This called for continuous evaluation and refinement of both the syntax, or formal elements (i.e. color, texture, line, size, position, etc.) of the design, and the semantics, or verbal and symbolic content of the design. These evaluations included cultural, social, environmental, political, and economic considerations. Elements for the composite message began with choosing a pair of photographs. Next students attached a single word to the pair of photographs, and finally, added a known brand identity mark.

The photographic pair was chosen from a visual comparison exercise completed the previous semester. Each pair of photos was related in either shape, texture, line continuation, or image-letterform. All pairs consisted of two equally sized squares, oriented horizontally or vertically.

The word element was derived from a process of list making and research on word origins and meanings, using the dictionary, thesaurus, association exercises, and online resources. Students carefully considered the valence of the word in combination with the semantic of the photographs: how it reinforced, opposed, or turned the overall narrative. In some cases, students exchanged word lists to break out of “designer’s block,” and engage lateral thinking.

Finally, a recognized brand identity mark (logo) was added, with the same considerations for its unique influence on the overall message. This further limited, focused, and defined the narrative in order to affect resonance, emotional response, and call to action.

The composite message was first developed in the context of the poster design. This served as a thematic model for the packaging and brochure, which followed. However, each application called for its own aesthetic and practical considerations. The packaging required an understanding of three-dimensional space and chronology. The small packages had to work separately, and as a unit, introducing modularity. The brochure design called for choices of format, and for the use of text as a supporting element, while remaining consistent with the established theme.

Timeline: 3 weeks / end of semester

Project 6: Self-promotional product

This final project had a practical application for the students and was less rigorously defined. Students created an attention-grabbing presentation on a self-selected theme that showcased their talents, with the proviso that it be practical as a personal-marketing tool targeting employers and clients. Since it was a self-promotion, some degree of self-expression was appropriate and encouraged.

Application: Self-promotion, promotion, marketing, public relations

Description: Design and production for self-promotion, format undefined

Procedure: Choice of format was left to each individual and divergent thinking was encouraged: 2-D, 3-D, and interactive work was acceptable. The project structure was minimal, but the work had to adhere to the principles of design excellence. In terms of learning theory the structure of this project could be viewed as constructivist.

The students began by creating a list of key words that described themselves, their work, inspirations, and their intentions, as a basis for creating a tangible product. Lists were shared with other students to promote divergent thinking and problem solving. Design and production proceeded at different paces depending on practical considerations.

Timeline: 3 weeks

Conclusion

This chapter detailed the methodology used to conduct the present study: the elements that constitute the study variables, and the instruments and procedures used to generate and gather the data. This provides the foundation for interpreting the results of analyses and findings reported in the next chapter.

4 RESULTS

Introduction

This chapter reports the results of the analysis of the data gathered for this study. Traditionally this chapter is a rather strict account of numbers generated by the analysis. However, since the study's intended audience is VCD educators and others in the design sciences, and the study's aim is to propose a framework for inquiry, explanations of the procedures have been included in the context of the results with the intent of making them accessible and replicable. The analyses begin with procedures that examine all the variables concurrently (correlation, multiple linear regression) and progress to methods that examine the relationships among the components of each of the primary variables (ANOVA, *t* tests). Table 4 presents descriptive statistics for the variables; raw scores appear in APPENDIX F p. 169.

Table 4

Descriptive Statistics for Study Variables

Variable	Min.	Max.	*M*	*Mdn*	*SD*
Transitional projects[a]	2.42	4.00	3.31	3.33	0.43
Cumulative GPA	2.40	3.95	3.26	3.25	0.41
Design GPA	2.33	4.00	3.48	3.67	0.46
Cumulative minus Design GPA[b]	2.02	4.02	3.13	3.19	0.50
Cognitive Style dimension 1: Holist-Analytic	0.73	2.12	1.26	1.20	0.27
Cognitive Style dimension 2: Verbal-Imagery	0.65	1.45	0.99	0.93	0.19
Learning Style dimension 1: AC-CE	-20.00	26.00	3.51	1.00	11.58
Learning Style dimension 2: AE-RO	-27.00	29.00	5.00	3.00	13.12

Note: N = 37, except as noted.
[a]Dependent variable; [b] n = 33, due to missing data in four cases.

Correlations

A common first step in evaluating multiple variables is to first to create a correlation matrix of all study variables to identify significant relationships and trends.

Correlations report the degree of relationship between variables. They do not imply causality, nor do they reveal the degree or source of influence of other variables on a pair. In addition, running correlations on all study variables may reveal “significant” relationships that are unrelated to the interests of the study; there is no way automatically to weed out spurious correlations caused by unincluded or unmeasured variables. Unlike multiple regression or ANOVA, bivariate correlation does not correct for inflation of estimates of significance that are the consequence of pooling multiple variables in a model. Nevertheless, carefully examining correlations at the outset may save time and refine the direction of subsequent procedures (Coladarci, Cobb, Minium, & Clarke, 2004; StatSoft Inc., 2010). Table 5 presents the correlation matrix for the variables.

Table 5

Correlation Matrix of the Study Variables.

	Trans. projects	Cum. GPA	Design GPA	Cum. minus Design GPA	Holist-Analytic	Verbal-Imagery	AC-CE	AE-RO
Transitional projects[a]	—							
Cumulative GPA	.13	—						
Design GPA	.33*	.65**	—					
Cumulative minus Design GPA[b]	-.07	.94**	.50**	—				
Holist-Analytic[c]	-.20	-.10	-.22	-.17	—			
Verbal-Imagery[d]	-.17	-.08	-.15	-.04	.38*	—		
AC-CE[e]	-.13	.03	.09	.00	.11	-.06	—	
AE-RO[f]	.03	.06	.28	-.07	.02	-.32	-.10	—

Note. Cum. = cumulative.
[a]Dependent variable; [b] weighted College GPA minus weighted studio GPA; [c] Cognitive style dimension 1; [d] Cognitive style dimension 2; [e] Learning style dimension 1; [f] Learning style dimension 2.
*significant at the .05 level (2-tailed); **significant at the .01 level (2-tailed).

The most important significant correlation is the positive relationship between design GPA, and Transitional Projects, $r(35) = .33$, $p = .04$. No other variables were significantly correlated with the DV.

Among the remaining variables, four correlations were statistically significant: (a) design GPA and Cumulative GPA, $r(35) = .65$, $p = .00$; (b) Cumulative GPA and cumulative minus design GPA, $r(31) = .94$, $p = .00$; (c) design GPA and cumulative minus design GPA, $r(31) = .50$, $p = .00$; and (d) Holist-Analytic and Verbal-Imagery, $r(35) = .38$, $p = .02$. The first three were expected, but are immaterial to the research questions.

The small positive correlation of Verbal-Imagery and Holist-Analytic indicates that students who are Holists also tend to be Verbalizers and that students that are Analytic tend to be Imagers. This was not expected since Riding's cognitive style model and normative samples predict that the Holist-Analytic and Verbal-Imagery dimensions are not correlated. So, although this appears to provide insight into the characteristics of our sample, it may also reflect a restriction of range due the sampling method and the small sample size. The large positive correlation between Cumulative GPA and cumulative minus design GPA presented a problem for multiple regression analysis because it indicates collinearity, meaning that including both variables in a regression would falsely inflate the correlation coefficient of the model (Saint-Germain, 2002). For that reason, and because cumulative minus design GPA was missing data for four cases, it was omitted from the regression analysis as discussed below.

Multiple Linear Regression

This subsection describes the details of the regression analyses performed in this study, beginning with concepts and mechanics: assumptions, multicolinearity, dummy coding, and the three methods used to construct models. Each part is followed by the results obtained by applying these to the study data.

Assumptions, Concerns, and Procedures

Assumptions. Multiple linear regression modeling typically begins with a preliminary evaluation of each IV to ensure that it meets the assumptions of normality, linearity, and homoscedasticity (see GLOSSARY OF TERMS, p. xvii). One approach is to conduct an initial exploratory regression of all variables and look at the residual scatter plot generated by the software. The pattern of the residuals, which are points representing the difference between each observed value of the dependent variable and the value predicted by the regression equation, should reveal a “pileup” of points in the center with a normal distribution of points trailing off symmetrically towards each end (Tabachnick & Fidell, 2001, p. 125; see Figure B1, APPENDIX B, p. 159). In addition to the residual plot, a box plot such as Figure 18, p. 120, is helpful in visually evaluating the individual variables since such plots provide quick information on the range and skew of variables. If these plots raise concerns, further tests can determine whether the concerns are significant.

In this study, the residual scatter plot shown in Figure B1 appears to verify the assumptions, but the box plot of design GPA in Figure 18 appears to deviate from normality and homoscedasticity. Note that the mean is clearly lower than the median, indicating a negative skew, which may violate the assumption of normality. A Kolmogorov-Smirnov test for normality showed that the distribution of design GPA did significantly deviate from normality, $K\text{-}S(37) = .22$, $p = .00$. However, the values for the skewness (-1.02), and the kurtosis (.096) of the curve fall within ± 2, which are acceptable values for both for psychometric research (Cutting, 2008).

Multicollinearity occurs when two or more IVs are so highly correlated that their influence is duplicated in the regression equation, inflating the value of the model. This can be assessed by prior examination of correlation coefficients among the IVs, and by using the variance inflation factors (VIF) test when the analysis is run. As mentioned in the previous section, the cumulative minus design GPA variable was omitted based its high correlation with Cumulative GPA. No other variables showed a VIF above 10 in all of the regression models (all IVs ≤ 5.77) and were therefore retained, as advised by

Stevens (2002).

Model building and data handling techniques. Regression models can be constructed in a variety of ways. This study used three: (a) entering all variables; (b) entering dummy-coded variables in blocks to isolate their influence; and (c) "automatically" by stepwise entry.

Regression uses the *R squared* (R^2), or multiple correlation coefficient to report the amount of variance in the DV predicted by the IV(s). When IVs are entered into regression equation in blocks, resulting in successive models, the *change in* R^2 statistic reports the contribution of additional blocks of variables from one model to the next. The F statistic, reported in an ANOVA table for the regression model, is used to determine the significance of the R^2 statistic and the model.

Dummy coding. Since multiple regression requires the use of continuous scale variables, those variables representing categories, or groups, must be numerically *dummy* coded to represent those categories. This means creating new variables for one fewer than the number of categories in a variable and assigning a value of 0 or 1 within each of those new variables to represent ranges of values in the source variable. In this scheme, one group receives all 0s, and is regarded as the "reference" group, while the other groups receive a value of 1 for the ranges of values they represent, and 0 for all other values. The reference group provides a kind of baseline for the comparison of the other groups and is not included in the regression equation except as its mean, which is the intercept value in the regression equation for that group of variables. In a regression plot this value is the point of the intercept of the regression line with the Y axis.

In this study the four Cognitive Style Type groups were defined by splitting the range of values in each of the two cognitive style dimensions, Holist-Analytic, and Verbal-Analytic, at their medians, and assigning the cases to one of the four Cognitive Style Types based on their scores. The Analytic-Verbal group was arbitrarily chosen as the reference group and was technically “left out” of the analysis. The Learning Style Type groups were similarly formed and the Accommodating group was chosen as the reference group. Obviously this results in some complexity when interpreting results since the statistical values of each of the dummy variables must be judged in terms of the implicit value of the reference group. The blocks of dummy variables were regressed in separate models to isolate them from the other IVs for a meaningful interpretation.

Stepwise entry. In stepwise entry, multiple IVs are added one at a time (by the software) based on the order of the largest correlation, and retained in the model if they contribute to an increase in overall statistical significance. It can be used as an exploratory or model-building technique and for eliminating superfluous variables (Tabachnick & Fidell, 2001). However, stepwise entry cannot account properly for dummy coded variables, so those blocks were entered manually in separate regression models, as mentioned above. When it was clear that the dummy coded variables did not contribute to the regression model, stepwise entry was used to isolate the only significant IV.

Application to This Study

Following the procedures outlined above, the first regression contained all of the continuous scale variables (excluding cumulative minus design GPA, as noted above). The resulting model showed no statistical significance as a predictor of performance on the transitional projects DV. Table B1, APPENDIX B, p. 159. presents the significance values and additional statistics for this regression model.

Second, neither of the separate regressions of the dummy coded cognitive style and learning style blocks yielded a significant model. These are presented in Tables B2 and B3, p. 160.

Finally, a stepwise regression was conducted. A statistically significant model emerged with studio GPA as the only predictor, R^2 = .11, adjusted R^2 = .09, F(1, 35) =

4.38, p = .04. None of the remaining IVs made a statistically significant contribution to the equation and were excluded. The adjusted R^2 = .09 indicated that 9% of the variance in transitional projects could be successfully predicted by design GPA. The coefficient for studio GPA, B = 0.31, indicated that each increase of 1.00 units in studio GPA resulted in an increase of 0.31 units in the Transitional Projects total (on a 4 point scale). For example, the regression equation predicts that students with a design GPA of 3.0 would score 3.15 on Transitional Projects ($Y' = a + b(X)$; $Y' = 2.22 + .31(3.0)$; = 3.15). These results are presented in Table B4, p. 161. The scatter plot with regression line is presented in Figure 17, below.

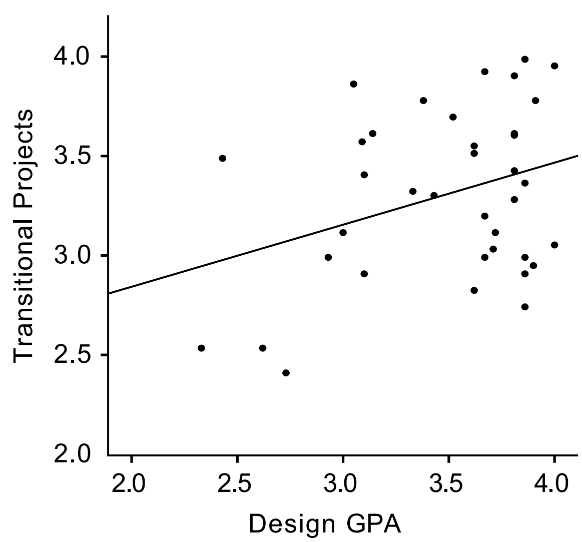

Figure 17. Distribution of design GPA scores regressed on transitional project scores with fit line.

Prior Academic Performance

This section reports descriptive statistics and analysis of the academic performance variables and their implications. These findings partially address research question one: *What is the relationship between VCD students' prior academic performance, cognitive style, and learning style, and their performance on Transitional Phase projects?* and three: *How can the knowledge created in this study be used to improve instructional design for the Transitional Phase in VCD programs?* Figure 18 graphically presents the descriptive statistics for these variables.

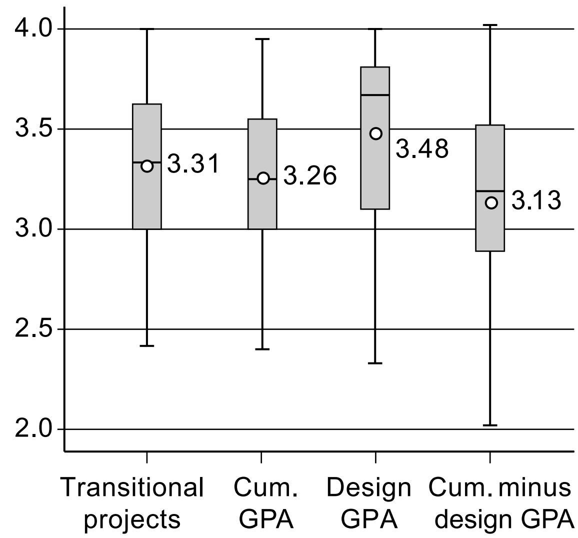

Figure 18. VCD student scores on the DV and academic IVs. Boxes with whiskers represent the range of scores and quartiles. Horizontal line in shaded area is the median, circle and adjacent label represent means.

A one-way ANOVA revealed a significant difference between the means, $F(3, 140) = 3.62$, $p = .02$.[1] Post hoc Bonferroni tests showed the source to be the difference between the high design GPA and low cumulative minus design GPA means, $p = .01$ (see Table C1, APPENDIX C, p. 163). This could indicate that, (a) VCD students perform better on design courses and projects than they do in overall liberal arts courses, (b) the grading standards in VCD courses are inflated compared to other courses, or (c) the influence of unidentified variable(s).

Interestingly, only six of the 33 cases had a higher cumulative GPA than cumulative minus design GPA (four cases were missing data, hence the $n = 33$). These frequencies proved statistically significant in a chi-square goodness-of-fit test, $\chi^2(1, N = 33) = 13.36$, $p = .00$, indicating the inflationary influence of design GPA on cumulative

[1] The ANOVA was performed by combining the scores for the four variables into a single variable and coding a new grouping variable that was used as a factor. This method permitted using ANOVA since each factor contained a sufficient number of cases: 37 for the first three variables, and 33 for the cumulative minus design GPA variable. Four cases were missing data necessary to calculate the latter variable, resulting in a smaller, but usable, *n*.

GPA. The negative skew of design GPA reveals a clustering of scores in the high end of the range with a few poor performers pulling out the low tail of the distribution.

Within-Sample Style Performance Comparisons

The findings presented in this subsection compare performance among cognitive and learning style preferences within the study's sample of VCD students. These address research question one: *What is the relationship between VCD students' prior academic performance, cognitive style, and learning style, and their performance in the Transitional Phase?*

Unlike the academic performance variables, our small sample size precluded the use of regression, or ANOVA, to explore these variables as sets since each of the Style Type groups are a subset of the 37 cases. As practical alternative, independent sample *t* tests were conducted on each dimension of the cognitive style and learning style models, and then on each pair of Cognitive Style Types and Learning Style Types to identify differences. To do this meaningfully, the sample's medians were used as split points to create groups of statistically equivalent size, eliminating any significant differences in group frequencies. The rationale for these procedures is discussed in detail under "Split points, factors, and cell sizes" in "METHODOLOGY," p. 99.

Cognitive Style Performance Comparisons

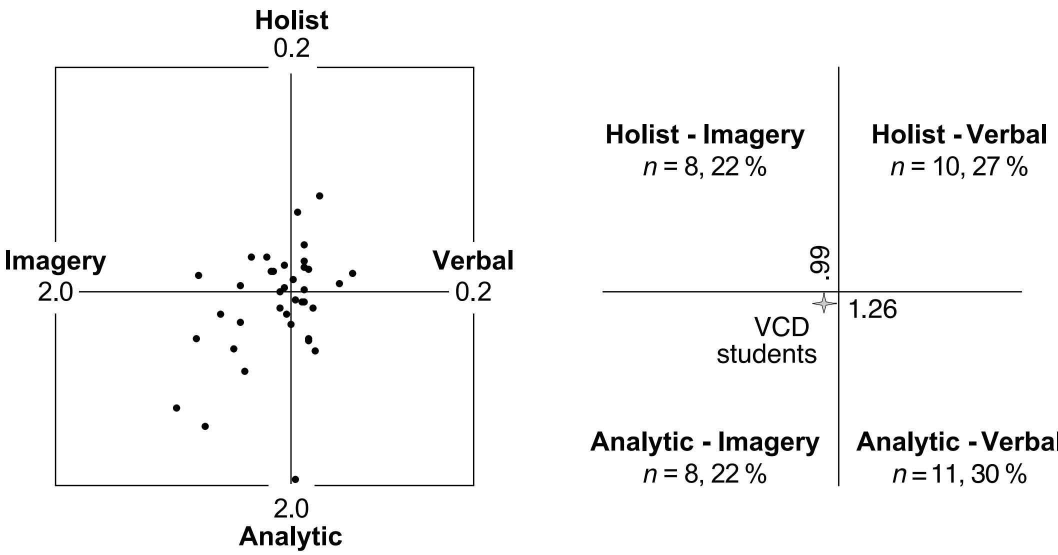

Figure 19. Distribution of Cognitive Style Types based on the median scores on each dimension within the sample: Holist-Analytic = 1.20, Verbal-Imagery = 0.93. Plot on right shows means for the entire sample on both primary dimensions (represented by the small cross), and frequencies for the four groups.

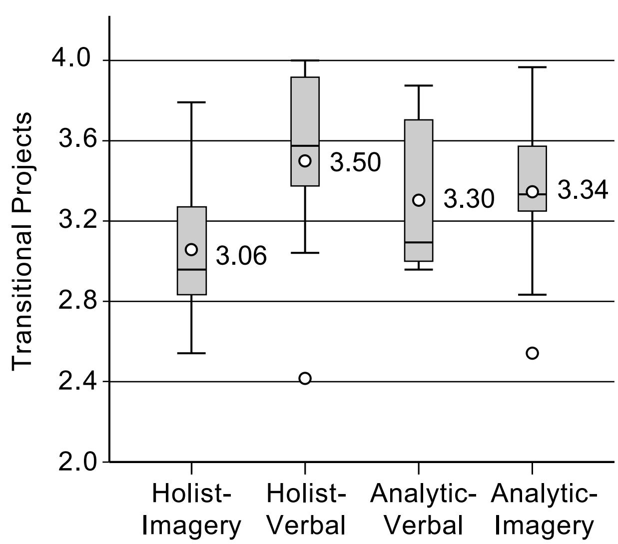

Figure 20. Cognitive Style Type mean scores on performance on Transitional Phase projects. Boxes with whiskers represent the range of scores and quartiles. Horizontal line in shaded area is the median, circle and adjacent label represent the group mean. Isolated circles represent extreme scores. Y axis trimmed to exclude values < 2.0.

Figure 19 presents the distribution, frequencies, and means of cognitive style for the sample using median split points. Figure 20 shows the range, median, and mean of each Cognitive Style Type score on the DV.

Independent samples *t* tests of the primary dimensions for differential performance on Transitional Phase projects, revealed no significant differences: Holist versus Analytic, $t(35) = -0.02$, $p = .98$; Verbal versus Imagery, $t(35) = 1.57$, $p = .13$. *t* tests of Cognitive Style Type for differential performance on Transitional Phase projects revealed one difference that approached the level of significance, between Holist-Imagery and Holist-Verbal, $t(16) = 2.09$, $p = .053$, suggesting that Holist-Verbal students may have a performance advantage over Holist-Imagery students. Although not statistically significant at the .05 level, this result offers a direction for further inquiry, which is considered in the "DISCUSSION" chapter. Comprehensive details of the analysis appear in APPENDIX D, Tables D1 and D2, p. 165.

Learning Style Performance Comparisons

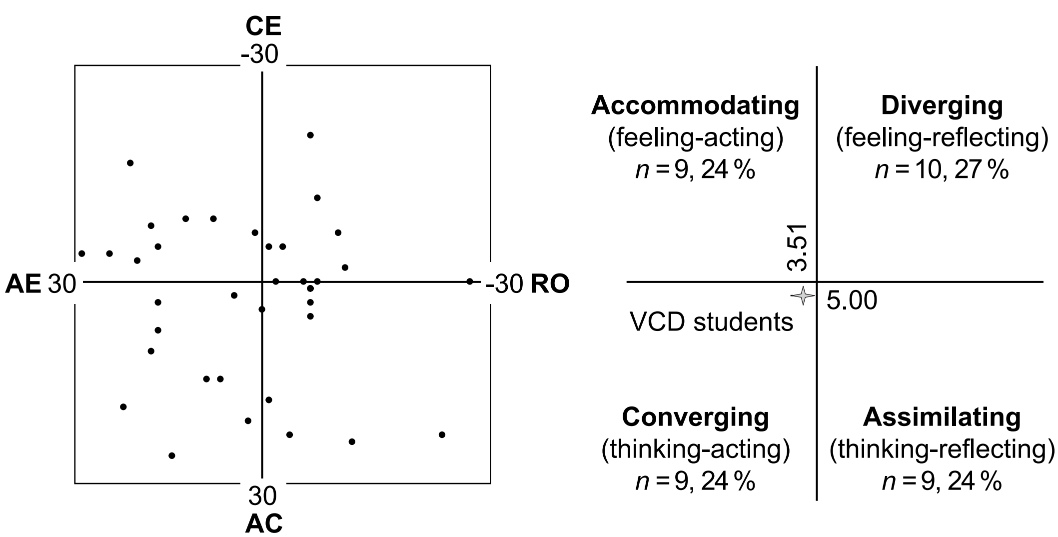

Figure 21. Distribution of Learning Style Types based on the median scores on each dimension within the sample: AC-CE = 1, AE-RO = 3. Plot on right shows means for the entire sample on both primary dimensions (represented by the small cross), and frequencies for the four groups.

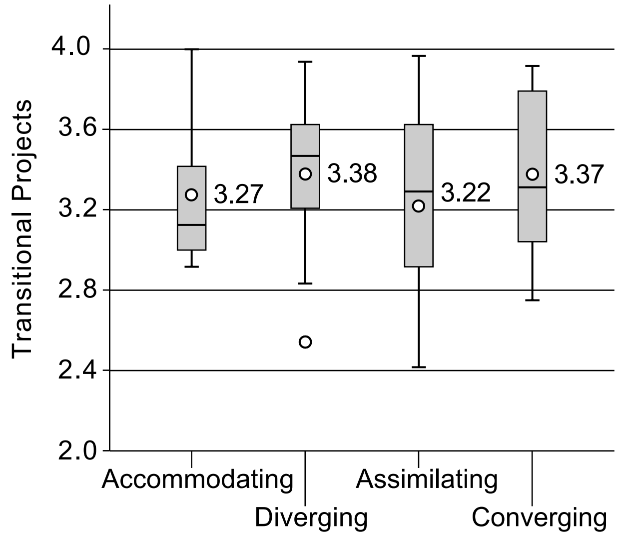

Figure 22. Learning Style Type mean scores on performance on Transitional Phase projects. Boxes with whiskers represent the range of scores and quartiles. Horizontal line in shaded area is the median, circle and adjacent label represent the group mean. Isolated circles represent extreme scores. Y axis trimmed to exclude values < 2.0.

Figure 21 presents the distribution, frequencies, and means of learning style for the sample using median split points. Figure 22 shows the range, median, and mean of each Learning Styles Type score on the DV.

Independent samples *t* tests of the primary dimensions for differential performance on Transitional Phase projects, revealed no significant differences: AC versus CE, $t(35) = 0.23$, $p = .82$; AE versus RO, $t(35) = -0.14$, $p = .89$. *t* tests of performance on Transitional Phase projects by Learning Style Type likewise revealed no significant differences, indicating no performance advantage or disadvantage for any Type. Comprehensive details appear in APPENDIX D, Tables D3 and D4, p. 166.

Between-Sample Style Preference Comparisons

The results in this section address research question three: *What cognitive style and learning style do VCD students prefer compared to other groups?* These were assessed by using single sample *t* tests to compare the mean scores of the VCD students on each primary cognitive style and learning style dimension to those of other design student and population samples.

Cognitive Style Preference Comparisons

The mean Holist-Analytic and Verbal-Imagery ratios captured by the CSA for the VCD sample were compared to the mean ratios from samples of:

- University students (presumably from the UK, or New Zealand), reported by Peterson (2003-2005);
- Architecture students, Welsh School of Architecture, Cardiff University, reported by Roberts (2007);
- Subjects from across the UK, population aged 11 – 65, reported by Riding (1991); and
- UK secondary school pupils, aged 14 –16, reported by Riding (1998).

On the Holist-Analytic dimension, single sample *t* tests revealed statistically significant differences with Robert's architecture students, $t(36) = -3.18$, p = .03, and Riding's UK secondary school sample, $t(36) = 3.11$, $p = .00$. The direction of the differences indicated that the VCD students showed a greater preference for Holist than Robert's architecture students, and a greater preference for Analytic than Riding's UK secondary school pupils.

On the Verbal-Imagery dimension *t* tests revealed statistically significant differences with all groups except Peterson's university students. Robert's architecture students: $t(36) = -2.68$, p = .01; Riding's UK general population: $t(36) = -2.35$, $p = .02$; Riding's UK secondary students: $t(36) = -3.66$, p = .00. The direction of the differences indicated that VCD students showed a greater preference for Verbal than Robert's architecture students, Riding's UK general population, and Riding's UK secondary school pupils. Of the four comparison samples the VCD students show the least difference with Peterson's university students, whose scores, she observed, "suggest little or no style preference" (Peterson, 2003-2005, p. 11).

The position of the above samples' means on the Cognitive Style Type grid appear in Figure 23. The crossbars represent Riding's 1991 normative sample split points only as a visual reference. Descriptive statistics appear in Table E1, APPENDIX E, p. 168.

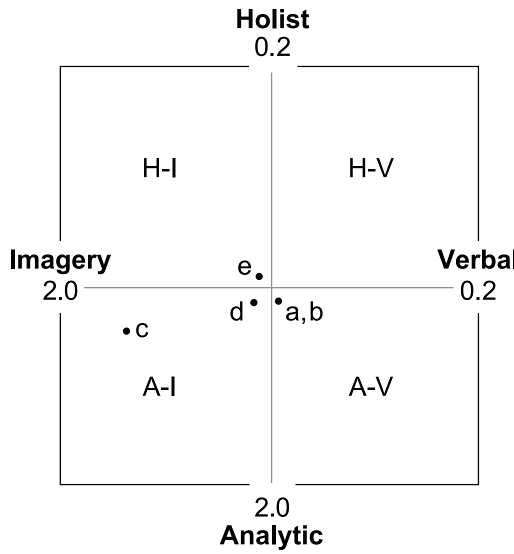

Figure 23. Distribution of cognitive style bivariate mean scores for VCD student sample and comparison samples. (a) VCD students; (b) University students (Peterson, 2003-2005); (c) Architecture students (Roberts, 2007); (d) UK population (Riding, 1991); (e) UK secondary school pupils (Riding, 1998). Crossbars represent Riding's 1991 normative split points for reference.

Learning Style Preference Comparisons

The mean AC-CE and AE-RO scores captured by the LSI for our VCD sample were compared to the mean scores from samples of:

- The LSI 3.1 normative sample, college students and working adults in a wide variety of fields, 80% US, reported by Kolb and Kolb (2005a);
- Liberal arts college students, enrolled in business courses at a private liberal arts college, average age 22, reported by Kolb and Kolb (2005a);
- Art college undergraduate students from three undergraduate art colleges, average age 20, reported by Kolb and Kolb, (2005a);

- Freshman architecture students, Bilkent University, Ankara Turkey, reported by Demirbas and Demirkan (2007).

On the AC-CE dimension, single sample *t* tests reveal a statistically significant difference with Kolb's liberal arts college students and Demirbas and Demirkan's freshman architecture students, $t(36) = -2.13$, $p = .04$, and $t(36) = -2.04$, $p = .05$, respectively. The direction of the difference indicates that the VCD students showed a greater preference for the CE style than Kolb's liberal arts students, and Demirbas and Demirkan's architecture students. On the AE-RO dimension, single sample *t* tests reveal no statistically significant differences.

Of the four comparison groups the VCD students show the least difference with Kolb's art college undergraduates on the AC-CE dimension, and Demirbas & Demirkan's architecture students on the AE-RO dimension. They also showed no significant difference on either dimension with Kolb and Kolb's (2005) normative sample. The position of these samples' means on the Learning Style Type grid appears in Figure 24. The crossbars indicate Kolb and Kolb's (2005a) normative sample split points only as a visual reference. Descriptive statistics appear in Table E2, APPENDIX E, p. 168.

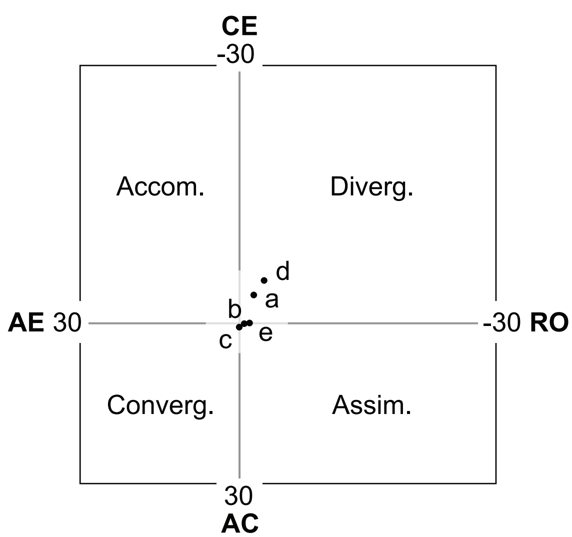

Figure 24. Distribution of learning style bivariate mean scores for VCD student sample and comparison samples. (a) VCD students; (b) LSI 3.1 normative sample (Kolb & Kolb,

2005a); (c) Liberal arts students (Kolb & Kolb, 2005a); (d) Art college undergraduates (Kolb & Kolb, 2005a); (e) Freshman architecture students (Demirbas & Demirkan, 2007). Crossbars represent Kolb and Kolb’s 2005 normative split points for reference.

Conclusion

The foregoing Chapter reported the results of the present study’s data analysis. This chapter also addressed the mechanics of the statistical methods used and the rationale for their use to address the three research questions. These complete the foundation for the following, “DISCUSSION,” chapter.

5 DISCUSSION

This chapter analyzes the results presented in the previous chapter and their relationship with the literature reviewed. It begins with a summary of general conclusions, followed by sections that discuss the results in detail. The second section addresses the research problem, the hypothesis, and research questions. The third section focuses on the implications for learning theory and instructional design, and the fourth section turns to suggestions for future research, and final observations.

General Conclusions

1. As the only significant predictor of Transitional Phase performance, design GPA should be a priority for future examination in research and selection procedures. In contrast, cumulative GPA should also be re-examined for the same reasons since it was not a significant predictor.
2. The results and literature reported in this paper support the view that university students with any cognitive or learning style may be successful in a VCD program, and that performance may depend on variables such as persistence and motivation more than on stylistic preferences. The *lack* of a statistically significant association between cognitive or learning style with performance supports the conclusions of other authors that stylistic versatility and non-specialization were a long-term performance advantage (Coffield et al., 2004a; Demirbas & Demirkan, 2003, 2007; Demirkan & Demirbas, 2008; Kvan, 2005; Roberts, 2006, 2007; Yukhina, 2007).
3. The present study found no evidence that matching teaching to a particular style would be helpful for learning. However, evidence was presented that knowledge about cognitive and learning styles are useful as a tool for learning and awareness.
4. Future research should attempt to maintain consistent methodologies,

terminology, and clarity of communication. The literature reviewed suggests that much confusion and misinterpretation could be avoided if authors were explicit about issues such as split points and the versions of instruments used. Comparing samples by using mean scores on primary dimensions of style models rather than normative split-points and group frequencies would also alleviate ambiguity. In addition, more studies are needed using culturally similar samples and methods of analysis in order to draw sound conclusions about comparisons, and to control for confounding factors.

Research Problem, Hypothesis, and Research Questions

This subsection reviews the results in terms of the research problem, hypothesis, and research questions.

Research problem: *How can knowledge of VCD students' prior academic performance, cognitive style, and learning style help predict future success and inform instructional design in the Transitional Phase of a VCD program?*

Hypothesis: *Prior academic performance, cognitive style, and learning style are associated with student performance during the Transitional Phase in VCD programs.*

Research Question One: Performance

What is the relationship between VCD students' prior academic performance, cognitive style, and learning style, and their performance in the Transitional Phase?

Prior academic performance. Since design GPA was the only significant predictor of performance during the Transitional Phase, the present study concludes that: (a) design GPA is a reliable criterion for admission to the upper level of programs, and should be retained; and (b) because design GPA and performance are correlated, it suggests that student awareness of that relationship at an early stage may provide motivation that could help students clarify and focus on their objectives, resulting in improved graduation ratios and persistence in the program.

Second, cumulative GPA was not a significant predictor of performance. This indicates that its usefulness as criterion for admission to the upper level of programs merits reexamination. Future research could examine both the design GPA and cumulative GPA of successive cohorts of students to establish the stability of this finding over time.

Third, two findings in this area, though not statistically significant, also suggest possibilities for future research to determine if the patterns they imply are stable over time. (a) the mean score on transitional projects was lower than design GPA (see Fig. 18, p. 120). This suggests that students found the Transitional Phase more challenging than previous coursework—one of the rationales for the present study. If this is found to be significant in a future study with a larger sample, research into interventions to improve performance in the Transitional Phase may prove fruitful. (b) the wider range of design GPA compared with cumulative GPA may indicate a problem with recruitment or acceptance into the program. This thought is supported by the negative skew of studio GPA, which suggests that a few individuals were poor performers, who pulled down the overall mean, and possibly should not have been admitted to the program (see Fig. 18, p. 120).

Fourth, as noted earlier, design GPA was statistically significantly higher than cumulative minus design GPA. This indicates that VCD students receive higher grades in design courses and projects than they do in general university courses. But it is unclear whether this is due to (a) grading standards in VCD courses being inflated compared to other courses, or (b) the influence of some other variable(s). Future research could be conducted to identify the mechanisms responsible for this effect.

Cognitive style. On the two primary dimensions of cognitive style the VCD sample showed no significant association of performance with style preference. Among the four Cognitive Style Types only one comparison approached significance, suggesting that Holist-Verbal may outperform Holist-Imagery students. This makes sense, given the strong verbal component inherent in VCD, especially in the mechanism of translating verbal and quantitative information into visual form. It may also reflect the bias of academia towards verbal communication. This also suggests an avenue for future scrutiny and interpretation.

Learning style. On the two primary dimensions of learning style the VCD sample also showed no significant association of performance with style preference, nor were any significant differences found among the four Learning Style Types, although Converging students had the highest scores. This points to the obvious conclusion that particular learning styles do not have an advantage in Transitional Phase projects, but also suggests that diverse or undifferentiated learning style preferences may be advantageous.

Research Question Two: Preference.

Which cognitive styles and learning styles do VCD students prefer compared to other groups?

Cognitive style. Our VCD student sample was significantly more Verbal and Holist than Roberts's (2007) architecture students, more Verbal and Analytic than Riding's (1998) secondary school students, and more Verbal than Riding's (1991) general population sample. The mean scores of our VCD sample were nearly identical on both dimensions with Peterson's (2003c) university student sample. Peterson noted that her distribution represented no clear style preference, indicating that the VCD students were stylistically undifferentiated and typical of university students.

The finding that VCD students were more Verbal than Riding's (1998) secondary school student, and (1991) general population samples arguably reflects the verbal bias of higher education. That VCD students were also more Analytic than the secondary school sample similarly may reflect the analytic bias and selection procedures of university education as noted by Coffield et al (2004a), Cohen (1969), and Coverdale and Zaveri (2003).

The finding that VCD students were significantly more Verbal and more Holist than Robert's (2007) architecture students calls into question the assumption that architecture students are appropriately analogous to VCD students for research purposes, and that the two are comparable examples of "design" students. Both Roberts (2007) and Yukhina (2007) found Verbal students disadvantaged in terms of performance and persistence in architecture programs. And since the VCD sample appears to reflect the typical preferences of university students in general (as represented in Peterson's, 2003 sample), it suggests that architecture students are more atypical and specialized in cognitive style preferences. Although these findings are suggestive, such conclusions will ultimately rest on the results of future studies—ones with greater control of unknown variables—such as parallel studies of VCD and architecture students within the same school or college.

The finding that VCD students were significantly more Holist than Robert's (2007) architecture students may reflect a tolerance of ambiguity and open-ended approach, combined with intuitive and flexible experimentation, that is required in VCD problem-solving. Those demands of immediacy may not be shared with architectural problem-solving.

Learning style. The VCD students showed no statistically significant differences with Kolb and Kolb's (2005a) normative sample on either primary dimension of learning style. However, VCD students did show a significantly greater preference for Concrete Experience on the *grasping*, or perceiving dimension (AC-CE), than Demirbas and Demirkan's (2007) architecture students, and Kolb and Kolb's (2005a) liberal arts students. This indicates that VCD students rely more on learning from immediate experience rather than through Abstract Conceptualization. This difference makes sense in terms of VCD problem solving, where sketching and experimenting with potential solutions can happen quickly and without costly consequences. By contrast, solutions to architectural problems typically involve more variables of a technical and engineering (and expensive) nature—knowledge of building materials, soil structure, planning and zoning issues, etc.—that may require more complex conceptualization and forethought. With regard to the difference with Kolb's liberal arts student sample, VCD student preference for Concrete Experience may also reflect an adaptation to the immediacy of the demands in VCD as compared to the broader complexion of general liberal arts education.

On the *transforming*, or processing dimension (AE–RO), there were no significant differences between the VCD students and other samples. This suggests that VCD requires versatility between the experimentation and reflection. It is arguable that specialization on this dimension is not an advantage because VCD decision making is typically fast-paced and requires an ability to shift rapidly between modes of processing information.

Research Question Three: Implications and Applications for Instructional Design.

How can the knowledge created in this study be used to improve instructional design for the Transitional Phase in VCD programs?

Cognitive and learning style. The analyses of data and review of literature reported in the present study support the consensus that stylistic specialization is of no particular advantage in design studio education and problem-solving. Stylistically intermediate students appear to have a long-term advantage since projects contain aspects of all cognitive and learning styles, and intermediate students are more versatile in adopting different approaches. Evidence was also presented that, although students with particular styles performed significantly better at various stages of the design process, the overall performance of cohorts either improved or converged over time regardless of cognitive or learning style preferences.

The absence of compelling evidence of a connection between styles and performance suggests that performance is more dependent on factors such as motivation, enthusiasm, and persistence. And, the analysis conducted in the present study suggests that students with the characteristics of liberal arts undergraduates, can be successful in a traditional VCD program regardless of their cognitive or learning style preferences.

Based on the above, this study concludes that there is insufficient evidence that the matching hypothesis has any positive consequences for VCD education. First, the concept and goals of matching are not sufficiently or meaningful defined, and rely on theoretical models that are not sufficiently substantiated, valid, or reliable.

Second, the variables that influence successful education are not confined to cognitive or learning style; unacknowledged variables such as teaching methods, setting, etc. influence the findings and conclusions of studies. This also argues against using style preference as a screening criterion for admission or for advancement in a program.

Third, the matching hypothesis is uncomfortably circular, particularly in the case of learning styles. Evidence was cited that students' styles change in the direction of instructional design over time (Kolb & Kolb, 2005a). If followed blindly, matching would reward changes in students' styles towards the instructional design, which in turn would restrict and reinforce the styles adopted by the students, which again would be promoted by the instructional design, etc. Yet, by the standards of matching, the whole affair might be judged a success—even if no learning took place. This is underscored by evidence that academia is already biased towards an abstract, analytic, and verbal orientation (Coffield et al., 2004a; Cohen, 1969; Coverdale & Zaveri, 2003; Kolb & Kolb, 2005a; Riding & Agrell, 1997).

Fourth, matching could promote policies contrary to education, development, and transference of knowledge. Rewarding some students, by shifting teaching to match their style, arguably would decrease those students' motivation and development, alienate students with other styles, and hinder the overall learning and development of an entire cohort. The opposing proposition, that all student style preferences should be meticulously identified and accommodated, is similarly problematic since it calls for exhaustive effort and expenditures for a result that is difficult to distinguish from conventional instructional design.

Given the foregoing, this study concludes that "matching" in VCD education should take the form of matching instruction to the content being taught—regardless of stylistic differences among learners. This is not advocacy for deliberately ignoring student preferences that *are* present. It makes sense for instructors to recognize the effectiveness of various styles for specific purposes, and for engaging students in dialog and awareness. But stylistic preferences are a secondary consideration to the problem-solving stragegies demanded in design projects.

Although evidence does not appear to support matching in design education, learning style theory can be useful for other purposes: (a) knowledge about learning styles can be used as a metacognitive tool to provide structure, enhance self-awareness, self-confidence and sense of control, to examine motivations, recognize individual differences, and highlight the value of different approaches (as suggested by Coffield et al., 2004a); (b) learning style theory also can provide a vocabulary or "lexicon of learning,"—a palpable structure for self-exploration—that can provide positive motivation especially for students with less confidence in their abilities or understanding of their learning (ibid.); (c) teams comprised of different Style Types collaborating on group projects may furnish a working example of the advantages of different approaches for specific goals, and also strengthen students' interpersonal communication skills for professional settings (Atkinson, 2004; Coffield et al., 2004a; Demirbas & Demirkan, 2003, 2007; Kvan & Yunyan, 2005; Roberts, 2006; Yukhina, 2007).

Theoretical implications and instructional design.

The Transitional Phase is not only a transition in the types of problems and problem solving but also a transition in the model of learning and instruction as illustrated in Figure 1. Students move from a behavioral model in the early semester(s), through cognitivism, and finally to a constructivist model. Each stage builds on the former, with the last being focused on autonomous construction of self-directed learning, and problem-solving in novel situations. Instructional design must be responsive as the program progresses through increasingly complicated and challenging stages. Ultimately, as noted by Patel (2008) “Design is learnable but not didactically or discursively teachable, it is critical to foster curious practical operations and experimentations” (p. 1).

Driscoll’s (1994) model for developing a “personal” learning theory (see p. 27), and McCown, Driscoll, and Roop’s (1996) “reflective construction” model (see p. 26), invite educators to develop their awareness of learning theory and combine it with their teaching experience in order to develop a theoretical system specific to the goals of their program, subject matter, and curriculum. In addition, Collins, Brown & Holum’s (1991) cognitive apprenticeship approach provides a promising formal structure for instructional design in VCD education (see pp. 55-60, & 87-97). Cognitive apprenticeship provides a kind of Swiss army knife of instructional design. It is situationally adaptable and responsive to innovations and changes in learning requirements as students advance through a program.

Adopting theoretical frameworks from other disciplines for such purposes is not new to VCD education. Semiotics is a analogous example that is widely accepted (see Ockerse & van Dijk, 1979). Ideally, these imports bring critical awareness, reflection, and clarification to implicit activities. Based on the knowledge created in the present study and the theory building and cognitive apprenticeship approaches discussed above, the balance of this subsection highlights several advantages these systems offer for VCD education.[1]

First, in addition to the advantages of cognitive apprenticeship as a method of instructional design, it is also useful as a metacognitive tool that educators and students can use for discussion and evaluation of learning and instruction. Similar to cognitive and learning style theory, bringing awareness of formal theoretical systems, their concepts and lexicon, to students empowers their experience and understanding, and facilitates cognitive development. Kelly (2001b) echoed: "If critical examination can be verbalized and incorporated into the thinking process, it is more consistently applied and students work at a higher level" (p. 85).

Second, the cognitive apprenticeship approach could be particularly productive as a basis for developing, refining, and empirically testing a variety of classroom innovations to help students develop metacognitive strategies, especially during the latter stages of a program. It can also be used as a framework to test and develop instruments to assess learning styles and other variables that may predict performance and success a program.

Third, the systematic approaches would seem particularly helpful to new faculty as a scaffold for developing tactics, projects, topical material, and a general approach to successful teaching. Although seasoned faculty typically have formulated successful approaches based on their years of experience and knowledge, most graduate students are not trained to be teachers, but to be scholars. The teaching experience gained during graduate school is frequently limited and not the primary focus of studies, often leaving them in the "lurch" if they pursue a teaching career. Or, as Boice, (2000) put it "Tradition in academe holds, mistakenly, that if you know your material, you can teach it" (p. 12).

[1] The author again acknowledges that there are many alternative approaches that could be helpful and that these are not the only ways to teach or learn VCD.

Finally, cognitive apprenticeship and the theoretical models reviewed above provide an established and recognized vocabulary for academic discourse and interdisciplinary collaboration. In this respect they also contribute to the professional credibility and status of the educational disciplines in which they are applied.

Future Research

The results of the present study generated a number of new research questions and directions for future study. Several of these were noted earlier in this DISCUSSION. This section presents additional ideas for (a) future study within the current limitations, and (b) opportunities for expanding study beyond the current limitations.

Within Current Limitations

This means retaining the same hypothesis, research questions, and variables, with improvements to methodology and tactics.

First, repeat the study with a larger sample. The small sample size limited the use of robust statistical analyses. As suggested by Roberts (2007), successive cohorts of students could be pooled, resulting in a large enough *N* to satisfy the assumptions of ANOVA and regression analyses. This has limitations in terms of statistical assumptions, but if the specific curriculum were shown to be consistent over time, the combined sample size could be large enough to support concurrent analysis of multiple variables. Demirbas and Demirkan (2007) and Demirkan and Demirbas (2008—note change in authors) also used this method to pool and evaluate three successive cohorts of freshman architecture students.

Second, address the power limitations of the study. An acknowledged limitation of the present study was the lack of a prior power analysis. Nevertheless, the present study obviously lacks power due to the small sample size and numerous independent variables. But, even if the sample was large enough, it would still be non-random, which violates the random-sample assumption of power analysis and parametric analysis. And, it may not be possible to replicate this study with a random sample since the research problem necessitates a purposive nonprobability sample.

Garson (2008) noted that in such cases there is no way to estimate significance or power other than with *bootstrapping* methods. These are statistical methods that emulate a larger original sample and allow the significance of a test statistic to be estimated when parametric assumptions cannot be honored. Bootstrapping creates an estimate of a population parameter by using *resampling* to draw many repeated samples from the original data set. Each drawn sample has the same number of cases as the original, but duplicate cases are randomly selected and included in each repeated sample. This results in hundreds, or thousands of new data sets. The statistic of interest is computed for each of these data sets, yielding an estimate of the distribution of the statistic, or population parameter.

Beyond Current Limitations

There are a variety of alternatives for expanding the present study beyond its current limitations while remaining faithful to its research interests and goals.

First, consider other variables that make sense in terms of the present results. For example, motivation was not included as a variable in the present study. Design GPA was the only significant predictor of performance and there were no significant performance advantages attributable to any single style, or combination of styles. This suggests that motivation (or commitment, or interest) may play a role in performance and success. Gender could also be of interest. Our sample contained more than twice the number of females as males (26 vs. 11 respectively) which precluded its use in any meaningful analysis of performance. However it not only raises the question of performance, but the intriguing question regarding the disparity in frequencies.

Second, use more meaningful statistics to examine a wider array of variables. For example, Hattie (1999) reported an extensive meta analysis of educational interventions, and concluded that effect size was much informative than statistical significance for judging the effectiveness of interventions. Interestingly, Hattie found that “reinforcement” was more effective in promoting student development than any other intervention in the 165,258 effects he reviewed.

Third, explore the differences between the styles of VCD professionals and VCD students. The literature reported findings that the learning styles of architecture students differed significantly from those of professional architects (Kvan & Yunyan, 2005; Kolb & Wolfe, 1981). It is reasonable to expect that professionals face different demands than students, and this raises questions about what those differences are, why they exist, and whether education should address them.

Fourth, use an instrument with better reliability and validity to study cognitive and learning styles. Most of the studies of cognitive and learning style in design education revealed by the literature search used Kolb’s LSI or Riding’s CSA. Other instruments are available that are more stable in terms of reliability and validity but have not been used extensively in studies of design education. For example, Allinson and Hayes’s *Cognitive Style Index,* Vermunt’s *Inventory of Learning Styles* (Coffield et al., 2004).

Fifth, combine qualitative and quantitative methodologies to study the same interests as those of the present study. As previously noted, this is particularly useful for exploratory purposes, for triangulating findings to isolate variables, and gaining new insights into theoretical architecture.

Finally, develop an instrument specifically valid and reliable for a particular VCD program. Critics lament the profusion of small-scale studies that use one-of-a-kind instruments, because they do not contribute to the external validity of popular instruments. But small studies inform future exploration. At a minimum they cast light on contrasting research interests, differences in samples, and educational goals. In that sense, they also can guide researchers in what *not* to do, or explore.

One-of-a-kind instruments could find use as a predictive and diagnostic tool for improving recruitment, student persistence, and instructional design. It would not necessarily generalize to other programs, and it would presuppose that a program maintain a consistent faculty, structure, and curriculum. In other words, to design an operational, valid, and reliable model and instrument to evaluate instructional design and student learning in a specific, limited, and stable, curricular setting. Coffield et al. (2004a) noted “A reliable and valid instrument which measures learning styles and approaches could be used as a tool to encourage self-development, not only by diagnosing how people learn, but by showing them how to enhance their learning” (p. 133).

Moreover, while the specifics of any particular model or instrument might not generalize to other settings, the research and development model proposed in this thesis could be profitably adapted to many other, very specific settings.

Conclusion

The Transitional Phase in VCD education represents a critical phase of development for students, and a significant shift in learning and teaching models for educators. The literature suggested that the variables of prior academic performance, cognitive style, and learning style would provide insight into predicting performance and improving instructional design within this Phase. This thesis explored those variables and evaluated them in the context of models of learning theory and instructional design.

The results, literature, and analysis support the conclusions that (a) the hypothesis was partially supported—performance in previous VCD courses (studio GPA) is the best predictor of future performance in the Transitional Phase, (b) intermediate or undifferentiated cognitive and learning style preferences are a long-term advantage to VCD students, (c) teaching and learning metacognitive strategies, supported by flexible and responsive systems of learning theory and instructional design, are appropriate and useful to VCD students and educators.

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APPENDIX A

SPLIT POINTS AND FREQUENCIES OF COGNITIVE AND LEARNING STYLE TYPE GROUPS

Table A1

Normative Split Points for Style Type Groups

Cognitive style[a]			Learning style[b]		
	HA	VI		AC-CE	AE-RO
Analytic-Verbal	> 1.18	≤ 1.04	Accommodating	≤ 7	≥ 7
Analytic-Imagery	> 1.18	> 1.04	Diverging	≤ 7	≤ 6
Holist-Imagery	≤ 1.18	> 1.04	Assimilating	≥ 8	≤ 6
Holist-Verbal	≤ 1.18	≤ 1.04	Converging	≥ 8	≥ 7

Note. HA = Holist-Analytic dimension; VI = Verbal–Imagery dimension; AC-CE = Abstract Conceptualization-Concrete Experience dimension; AE-RO = Active Experimentation-Reflective Observation dimension.
[a]split points based on Riding (1991); [b]split points based on Kolb and Kolb (2005a)

Table A2

Frequencies of Cases Within Style Type Groups Based on Normative Split Points

Cognitive style[a]			Learning style[b]		
	Freq. (*n*)	Percent		Freq. (*n*)	Percent
Holist-Imagery	3	8.1	Accommodating	10	27.0
Holist-Verbal	14	37.8	Diverging	16	43.2
Analytic-Verbal	13	35.1	Assimilating	5	13.5
Analytic-Imagery	7	18.9	Converging	6	16.2
Total	37	100.0		37	100.0

Note. [a]split points based on Riding, 1991; [b]split points based on Kolb and Kolb, 2005.

Table A3

Median (Within-Sample) Split Points for Style Type Groups

Cognitive style			Learning style		
	HA[a]	VI[b]		AC-CE[c]	AE-RO[d]
Analytic-Verbal	> 1.20	≤ 0.93	Accommodating	≤ 1	> 3
Analytic-Imagery	> 1.20	> 0.93	Diverging	≤ 1	≤ 3
Holist-Imagery	≤ 1.20	> 0.93	Assimilating	> 1	≤ 3
Holist-Verbal	≤ 1.20	≤ 0.93	Converging	> 1	> 3

Note. [a]HA = Holist-Analytic dimension; [b]VI = Verbal–Imagery dimension; [c]AC-CE = Abstract Conceptualization-Concrete Experience dimension; [d]AE-RO = Active Experimentation-Reflective Observation dimension.

Table A4

Frequencies of Cases Within Style Type Groups Based on Median Split Points

Cognitive style[a]			Learning style[b]		
	Freq. (*n*)	Percent		Freq. (*n*)	Percent
Holist-Imagery	8	21.6	Accommodating	9	24.3
Holist-Verbal	10	27.0	Diverging	10	27.0
Analytic-Verbal	8	21.6	Assimilating	9	24.3
Analytic-Imagery	11	29.7	Converging	9	24.3
	37	100.0	Total	37	100.0

Note. [a]Cognitive Style medians: Holist-Analytic = 1.20, Verbal-Imagery = 0.93; [b]Learning Style medians: AC-CE = 1.00, AE-RO = 3.00.

APPENDIX B

REGRESSION FIGURE AND TABLES

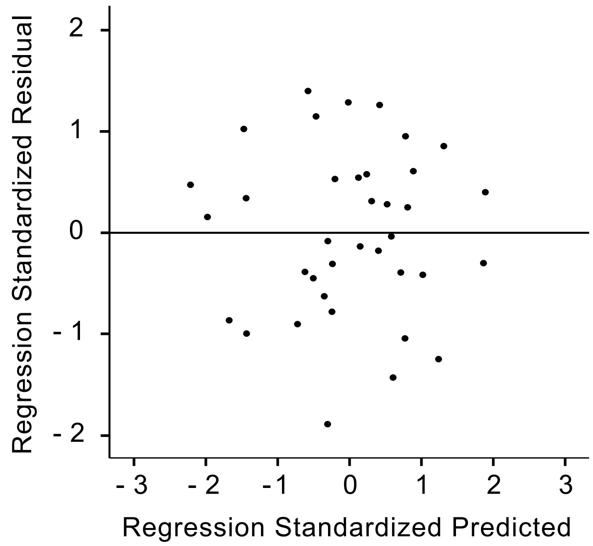

Figure B1. Residual scatter plot for all variables in regression 1.

Table B1

Summary of Regression 1

Variable	*B*	*SE B*	ß	*t*	*p*	95% CI
(Constant)	2.83	0.82		3.46		[1.16, 4.50]
Cumulative GPA	-0.20	0.23	-0.19	-0.86	.40	[-0.67, 0.27]
Design GPA	0.46	0.22	0.49	2.08	.05	[0.01, 0.92]
CS dim. 1: Holist-Analytic[a]	-0.03	0.30	-0.02	-0.10	.92	[-0.64, 0.58]
CS dim. 2: Verbal-Imagery[a]	-0.40	0.44	-0.17	-0.88	.39	[-1.30, 0.52]
LS dim. 1: AC-CE[a]	-0.01	0.01	-0.19	-1.13	.27	[-0.02, 0.01]
LS dim. 2: AE-RO[a]	-0.01	0.01	-0.18	-0.92	.37	[-0.02, 0.01]
R	.44					
R^2	.19					
Adjusted R^2	.03					
Change in R^2						
F	1.19					
Change in *F*						
p of *F* [b]	.34					

Note. *N* = 37; Dependent variable: Transitional Projects; CI = confidence interval; CS = cognitive style; LS = learning style; dim. = dimension; *SE* = standard error.
[a]Continuous scale variable representing theoretical style dimension. [b]Significance value of the model.

Table B2

Summary of Regression 2: Regression of Cognitive Style Type on Transitional Projects (dummy coded)

Variable	*B*	*SE B*	ß	*t*	*p*	95% CI
(Constant)	3.30	0.15		22.42		[3.00, 3.60]
Analytic-Imagery	0.04	0.34	0.04	0.20	.85	[-036, 0.43]
Holist-Imager	-0.25	0.21	-0.24	-1.18	.25	[-0.67, 0.18]
Holist-Verbalizer	0.20	0.20	0.20	0.98	.33	[-0.21, 0.60]
R	.36					
R^2	.13					
Adjusted R^2	.05					
F	1.68					
p for *F* [a]	.19					

Note. *N* = 37; style type groups created using sample's median splits; dependent variable: Transitional Projects; CI = confidence interval; *SE* = standard error.
[a]Significance value of the model.

Table B3

Summary of Regression 3: Regression of Learning Style Type on Transitional Projects (dummy coded)

Variable	*B*	*SE B*	ß	*t*	*p*	95% CI
(Constant)	3.28	0.15		22.24		[2.96, 3.58]
Diverging	0.10	0.20	0.11	0.51	.61	[-0.31, 0.52]
Assimilating	-0.54	0.21	-0.06	-0.26	.80	[-0.48, 0.37]
Converging	0.10	0.21	0.10	0.47	.64	[-0.32, 0.52]
R	.16					
R^2	.02					
Adjusted R^2	-.06					
F	0.28					
p for *F* [a]	.84					

Note. *N* = 37; style type groups created using sample's median splits; dependent variable: Transitional Projects; CI = confidence interval; *SE* = standard error.
[a]Significance value of the model.

Table B4

Summary of Regression 4: Stepwise Regression of Variables Predicting Student Success on Transitional Projects

Variable	*B*	*SE B*	ß	*t*	*p*	95% CI
(Constant)	2.22	0.52		4.24		[1.16, 3.29]
Design GPA	0.31	0.15	0.33	2.09	.04	[0.01, 0.62]
R	.33					
R^2	.11					
Adjusted R^2	.09					
F	4.38*					
p for F [a]	.04					

Note. N = 37; Dependent variable: Transitional Projects; CI = confidence interval; *SE* = standard error.
[a]Significance value of the model.
*$p < .05$.

APPENDIX C

ACADEMIC PERFORMANCE ANOVA POST HOC TESTS

Table C1

Mean Differences of Academic Performance Scores using Bonferroni post hoc comparisons based on a one-way ANOVA

Variable	*M*	*SD*	Trans. projects	Cum. GPA	Design GPA
Transitional projects	3.31	0.43			
Cumulative GPA	3.26	0.41	0.06		
Design GPA	3.48	0.46	-0.16	-0.22	
Cumulative minus design GPA	3.13	0.50	0.18	0.12	0.35**

Note. Dependent variable: Transitional Projects; CI = confidence interval;
SD = standard deviation.
**means are significantly different at $p = .01$.

APPENDIX D

WITHIN-SAMPLE COGNITIVE AND LEARNING STYLE *T* TEST TABLES

Table D1

Independent samples t *test Comparisons of Performance on Transitional Phase Projects by Cognitive Style Dimension*

Dimension	*n*	*t*	*df*	*p*	Mean difference
Holist-Analytic	19, 18	-0.02	35	.98	-0.00
Verbal-Imagery	19, 18	1.57	35	.13	0.22

Note. Split points based on sample medians: Holist-Analytic = 1.20, Verbal-Imagery = 0.93.

Table D2

Independent samples t *test Comparisons of Performance on Transitional Phase Projects by Cognitive Style Type*

Group pairs	*t*	*df*	*p*	Mean difference
Analytic-Verbal Analytic-Imagery	-0.21	17	.84	-0.95
Analytic-Verbal Holist-Imagery	-1.26	14	.23	-6.16
Analytic-Verbal Holist-Verbal	0.99	16	.37	4.87
Analytic-Imagery Holist-Imagery	-1.57	17	.14	-7.11
Analytic-Imagery Holist-Verbal	0.82	19	.42	3.92
Holist-Imagery Holist-Verbal	2.09	16	.05*	11.03

Note. Split points based on sample medians: Holist-Analytic = 1.20, Verbal-Imagery = 0.93; *N* = 37.
**p* = .05.

Table D3

Independent samples t *test Comparisons of Performance on Transitional Phase Projects by Learning Style Dimension*

Dimension	*n*	*t*	*df*	*p*	Mean difference
AC-CE	18, 19	0.23	35	.82	0.03
AE-RO	18, 19	-0.14	35	.89	-0.02

Note. AC = Abstract Conceptualization, CE = Concrete Experience, AE = Active Experimentation, RO = Reflective Observation. Split points based on sample medians: AC-CE = 1, AE-RO = 3.

Table D4

Independent samples t *test Comparisons of Performance on Transitional Phase Projects by Learning Style Type*

Group pairs	*t*	*df*	*p*	Mean difference
Accommodating vs. Diverging	-0.58	17	.57	-2.10
Accommodating vs. Assimilating	0.25	16	.80	0.05
Accommodating vs. Converging	-0.53	16	.60	-0.10
Diverging vs. Assimilating	-0.71	17	.48	0.16
Diverging vs. Converging	0.03	17	.98	-3.56
Assimilating vs. Converging	-0.66	16	.52	-0.15

Note. Split points based on sample medians: AC-CE = 1, AE-RO = 3; *N* = 37.

APPENDIX E

BETWEEN-SAMPLE COGNITIVE AND LEARNING STYLE *T* TEST TABLES

Table E1

Single sample t *test Comparisons of Cognitive Style Means*

		Holist–analytic		Verbal-Imagery	
Sample	*N*	*M*	*SD*	*M*	*SD*
VCD students[a]	37	1.26	.27	.99	.19
University students[b]	276, 376	1.25	.31	.99	.41
Architecture students[c]	120	1.40*	.57	1.07*	.16
UK general population[d]	999	1.25	.45	1.06*	.20
UK secondary school pupils[e]	1448	1.12*	.46	1.10*	.27

Note. [a]Students in the present study; [b]Peterson, 2003c; [c]Roberts, 2007; [d]Riding, 1991; [e]Riding, 1998
*Significantly different from VCD student sample at $p < .05$

Table E2

Single sample t *test Comparisons of Learning Style Means*

		AC-CE		AE-RO	
Sample	*N*	*M*	*SD*	*M*	*SD*
VCD students[a]	37	3.51	11.58	5.00	13.12
LSI norm group[b]	6977	6.83	11.69	5.96	11.63
Lib. arts college students[c]	221	7.56*	10.34	6.80	12.37
Art college undergraduates[d]	813	1.00	11.13	3.73	11.49
Freshman architecture students[e]	273	7.41*	9.46	5.47	8.23

Note. [a]Students in the present study; [b]Kolb & Kolb, 2005; [c]Kolb & Kolb, 2005; [d]Kolb & Kolb, 2005; [e]Demirbas & Demirkan, 2007
*Significantly different from VCD student sample at $p < .05$

APPENDIX F

RAW SCORE TABLES

Table F1

VCD Students' Academic Performance Data Raw Scores Sorted by Descending Order of Transitional Projects Score

Case ID	Transitional Projects[a]	Cumulative GPA	Design GPA	Cumulative minus Design GPA
33	4.00	3.25	3.86	3.06
34	3.97	3.65	4.00	3.54
38	3.94	3.29	3.67	2.91
22	3.92	2.99	3.81	2.58
10	3.87	2.53	3.05	2.02
25	3.79	3.69	3.91	3.47
29	3.79	3.10	3.38	3.01
1	3.71	3.28	3.52	3.19
3	3.62	2.40	3.14	2.15
32	3.62	3.75	3.81	3.70
35	3.62	3.72	3.81	3.67
13	3.58	2.64	3.09	2.51
2	3.56	3.16	3.62	2.90
23	3.52	3.78	3.62	3.86
37	3.50	3.19	2.43	—
26	3.44	3.76	3.81	3.73
28	3.42	3.17	3.10	3.20
12	3.37	3.48	3.86	3.33
30	3.33	2.82	3.33	2.46
24	3.31	2.99	3.43	2.82
15	3.29	3.95	3.81	4.02
27	3.21	3.24	3.67	3.08
17	3.12	3.55	3.72	3.47
36	3.12	3.33	3.00	3.52
21	3.06	3.18	4.00	—
31	3.04	3.48	3.71	3.39

Note. [a]Dependent variable; [b]Scores are presented on a 4 point scale for convenience of comparison with GPA scores, and were calculated by multiplying the 100 point scores by .04. This inflated the lowest scores as compared with ASU's grade scale algorithm, but preserved rank order and data, and is consistent with the detail presented in the cumulative GPA scores.

Table F1

VCD Students' Academic Performance Data Raw Scores Sorted by Descending Order of Transitional Projects Score

Case ID	Transitional Projects[a]	Cumulative GPA	Design GPA	Cumulative minus Design GPA
7	3.00	3.52	2.93	—
18	3.00	3.03	3.86	2.47
20	3.00	3.59	3.67	3.53
16	2.96	3.84	3.90	3.80
9	2.92	3.00	3.10	2.97
11	2.92	3.48	3.86	3.27
6	2.83	3.19	3.62	2.89
19	2.75	3.50	3.86	3.27
4	2.54	2.50	2.33	2.57
5	2.54	2.82	2.62	2.97
8	2.42	2.60	2.73	—

Note. [a]Dependent variable; [b]Scores are presented on a 4 point scale for convenience of comparison with GPA scores, and were calculated by multiplying the 100 point scores by .04. This inflated the lowest scores as compared with ASU's grade scale algorithm, but preserved rank order and data, and is consistent with the detail presented in the cumulative GPA scores.

Table F2

VCD Students' Cognitive Style Analysis Mean Ratio Scores

Case ID	Mean Verbal-Imagery (VI)	Mean Holist-Analytic (HA)
1	0.92	1.14
2	0.93	1.36
3	0.98	1.28
4	1.01	1.10
5	1.45	1.77
6	0.95	1.31
7	0.91	2.12
8	0.71	1.16
9	0.96	1.07
10	0.85	1.43

Table F2

VCD Students' Cognitive Style Analysis Mean Ratio Scores

Case ID	Mean Verbal-Imagery (VI)	Mean Holist-Analytic (HA)
11	1.35	1.12
12	0.90	0.81
13	1.19	1.48
14	1.36	1.43
15	0.85	1.44
16	0.82	1.49
17	0.96	1.18
18	1.04	1.03
19	0.87	1.25
20	0.91	1.24
21	0.65	1.11
22	0.85	1.09
23	1.14	1.59
24	0.88	1.25
25	0.87	1.19
26	1.32	1.86
27	1.11	1.03
28	1.16	1.17
29	1.16	1.35
30	0.87	1.08
31	0.80	0.73
32	0.87	1.05
33	1.25	1.31
34	0.83	1.28
35	1.02	1.10
36	0.98	1.20
37	0.87	0.97

Table F3

VCD Students' Learning Style Inventory Scores

Case ID	Abstract Conceptualization - Concrete Experience (AC-CE)	Active Experimentation - Reflective Observation (AE-RO)
1	23	-1
2	-8	14
3	5	3
4	-1	-9
5	6	-4
6	1	-3
7	15	9
8	2	-4
9	24	-10
10	15	11
11	-6	4
12	-3	29
13	-4	2
14	20	-2
15	4	-4
16	-3	25
17	-7	19
18	-4	18
19	26	16
20	18	2
21	11	19
22	19	23
23	2	-4
24	3	7
25	8	18
26	-4	0
27	1	-5
28	-2	21
29	-6	-8

Table F3

VCD Students' Learning Style Inventory Scores

Case ID	Abstract Conceptualization - Concrete Experience (AC-CE)	Active Experimentation - Reflective Observation (AE-RO)
30	1	1
31	21	5
32	1	-27
33	-16	22
34	23	-23
35	4	18
36	-8	10
37	-11	-5
38	-20	-4

APPENDIX G

A INSTITUTIONAL REVIEW BOARD APPROVAL

ARIZONA STATE UNIVERSITY

Research Compliance Office
Office for Research & Sponsored Projects Administration
P.O. Box 873503
Tempe, AZ 85287-3503

Phone
(480) 965-6788
Facsimile
(480) 965-7772

To:	Alfred Sanft ARCH 212
From:	Mark Roosa, Chair Institutional Review Board
Date:	04/18/2007
Committee Action:	**Exemption Granted**
IRB Action Date:	04/18/2007
IRB Protocol #:	0704001760
Study Title:	Form to Function: The Transition to Applied Problems in Visual Communication Design Curriculum

The above-referenced protocol is considered exempt after review by the Institutional Review Board pursuant to Federal regulations, 45 CFR Part 46.101(b)(1) .

This part of the federal regulations requires that the information be recorded by investigators in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects. It is necessary that the information obtained not be such that if disclosed outside the research, it could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.

You should retain a copy of this letter for your records.

Figure G1. ASU Institutional Review Board exemption from human subject research requirements.

CONSENT FORM
Form to function: The transition to applied problems in visual communication design curriculum

INTRODUCTON
The purposes of this form are to provide you (as a prospective research study participant) information that may affect your decision as to whether or not to participate in this research and to record the consent of those who agree to be involved in the study.

RESEARCHERS

Alfred Sanft Associate Professor College of Design Arizona State University (Principal Investigator)	John Murdock MSD Candidate College of Design Arizona State University (Co-investigator)

have invited your participation in

STUDY PURPOSE
The purpose of this research is to improve the Visual Communication Design Program at ASU for students, through a better understanding of students' preferences and needs.

DESCRIPTION OF RESEARCH STUDY
If you decide to participate, then you will join a study involving research of how design students' scholastic performance, personality type, learning style preferences, cognitive style, and specific cognitive abilities may associate with their success with third-year applied projects in the Visual Communication Design Program.

If you say YES, then your participation will last for approximately 1.75 hours, divided over several sessions in the next two weeks in this classroom and another room in this building (CDN). You will be asked to complete several relatively simple paper and pencil exercises and one computer-based exercise. By saying YES you also grant permission to the Principal Investigator (Alfred Sanft) to obtain your academic records including SAT score and GPA for use in the study. The Co-investigator will only have access to these academic records as identified by your coded nickname. In addition, several volunteers will be asked to participate in a brief interview about their experience in the third year of the Visual Communication Design Program. Individual interviews will be audio taped, but interviewees will not be identified.

Approximately 38 subjects will be participating in this study.

RISKS
There are no known risks from taking part in this study, but in any research, there is some possibility that you may be subject to risks that have not yet been identified.

BENEFITS
Your participation in this research study will help the Visual Communication Design Program faculty improve the Program for this class and future classes. Copies of the completed study will be made available to you as a resource for understanding your educational experience in the Visual Communication Design Program.

CONFIDENTIALITY
All information obtained in this study is strictly confidential. The results of this research study may be used in reports, presentations, and publications, but the researchers will not identify you. In order to maintain confidentiality of your records, Alfred Sanft and John Murdock will identify all participants by a nickname chosen by each participant. The researchers will maintain subject anonymity by dividing data gathering and sharing. Neither investigator will have access to both the full data set and the participants' identities. The co-investigator (John Murdock) will never know participant identities. All records and data collected will be kept in a locked cabinet and filed until the study is completed, after which they will be destroyed. Any audio recordings will also be kept in a locked cabinet and filed until the study is completed, after which they will be erased.

WITHDRAWAL PRIVILEGE
Participation in this study is completely voluntary. It is ok for you to say no. Even if you say yes now, you are free to say no later, and withdraw from the study at any time. Nonparticipation or withdrawal from the study will not affect your grade, or your standing in the Visual Communication Design Program. You are also free to refuse to answer any question you wish. If you withdraw, any tapes and/or data recorded or collected on will be destroyed immediately.

COSTS AND PAYMENTS
The researchers want your decision about participating in the study to be absolutely voluntary. Yet they recognize that your participation may pose some inconvenience. In order to help compensate you for your time

Figure G2. Subject consent form, page 1.

you may receive payment. Participants in the study (interview excluded) are offered a payment by check of $10.00 upon completion of their participation.

VOLUNTARY CONSENT
Any questions you have concerning the research study or your participation in the study, before or after your consent, will be answered by:

Alfred Sanft
Arizona State University
College of Design South (CDS)
Rm. 212
Tempe, AZ 85287-1905

alfred.sanft@asu.edu
ph: 480.965.3238

John B. Murdock
1502 W Alamo Dr
Chandler, AZ 85224

john.murdock@asu.edu
480.726.1740

If you have questions about your rights as a subject/participant in this research, or if you feel you have been placed at risk, you can contact the Chair of the Human Subjects Institutional Review Board, through the ASU Research Compliance Office, at 480-965 6788.

This form explains the nature, demands, benefits and any risk of the project. By signing this form you agree knowingly to assume any risks involved. Remember, your participation is voluntary. You may choose not to participate or to withdraw your consent and discontinue participation at any time without penalty or loss of benefit. In signing this consent form, you are not waiving any legal claims, rights, or remedies. A copy of this consent form will be offered to you.

Your signature below indicates that you consent to participate in the above study.

______ (Initials) Yes, I wish to participate in a brief interview, and grant the researcher permission to anonymously audiotape the interview.

______ (Initials) No, I do not want to participate in a brief interview.

_____________________________ _____________________________ __________________
Subject's Signature Printed Name Date

INVESTIGATOR'S STATEMENT
"I certify that I have explained to the above individual the nature and purpose, the potential benefits and possible risks associated with participation in this research study, have answered any questions that have been raised, and have witnessed the above signature. These elements of Informed Consent conform to the Assurance given by Arizona State University to the Office for Human Research Protections to protect the rights of human subjects. I have provided offered the subject/participant a copy of this signed consent document."

______________________________________ __________________
Signature of Investigator Date

Figure G3. Subject consent form, page 2.

APPENDIX H

INSTRUMENT LICENSES

LICENCE AGREEMENT

between

THE UNIVERSITY COURT OF THE UNIVERSITY OF EDINBURGH, having its principal office at Old College, South Bridge, Edinburgh EH8 9YL, UK ("the University")

and

JOHN MURDOCK, residing at 1502 W Alamo Drive, Chandler, AZ 85224, USA ("the Licensee")

BACKGROUND

(A) The University is the proprietor of certain Intellectual Property Rights (as defined below) in the Software (as defined below);

(B) The Licensee wishes to acquire a licence to the Software for its own academic research purposes in the Field (as defined below); and

(C) The University and the Licensee have agreed that the University will licence the Software to the Licensee upon the terms and conditions of this Agreement.

TERMS AND CONDITIONS

It is hereby agreed as follows:

1. Interpretation

1.1 In this Agreement, unless the context requires otherwise, the following words and phrases shall have the meanings set opposite them:

"Commencement Date"	means the last day of execution of this Agreement;
"Documentation"	means the documentation provided by the Licensor for the Software, in either printed text or machine readable form;
"Field"	means the field of psychology education, business and management;
"Improvements"	shall have the meaning given in Clause 4.2;
"Intellectual Property Rights"	means patents, trade marks, registered designs (and applications for any of them) copyright, unregistered design rights, database rights or other rights in databases, semiconductor topography rights, trade names, trade secrets or confidential information of any sort, and any similar or analogous rights as may apply anywhere in the world;
"Licence Term"	means the period of 12 months commencing on the Commencement Date;
"Results"	means without limitation, all data, information, samples, materials, processes, procedures, reports and documents of any kind as are generated by the Licensee as a direct result of the use of the Software by the Licensee;
"Schedule"	means the schedule annexed hereto and forming part of this Agreement;

PSYCHOL009. Licence Agreement. VICS & Extended CSA-WA. 26.03.07 Page 1 of 6

Figure H1. License agreement and permission for use of Peterson's VICS and Extended CSA-WA tests, page 1.

"Software"	means the Verbal Imagery Cognitive Style "VICS" developed by Dr Elizabeth Peterson based on the verbal-imagery dimension of the Cognitive Styles Analysis test developed by Dr Richard Riding, as described in the Schedule; and the Extended Cognitive Styles Analysis Test of the Wholistic-Analytic Dimension "Extended CSA-WA" which consists of the wholistic-analytic dimension of the CSA ("CSA-WA") developed by Dr Richard Riding and the extension of this test developed by Dr Elizabeth Peterson, as described in the Schedule;
"Territory"	means worldwide;
"Use"	means the right of the Licensee to load, execute, store, transmit, display, copy or develop the Software.

1.2 In this Agreement:

1.2.1 unless otherwise stated, references to Clauses are to Clauses in this Agreement;

1.2.2 the Clause headings are for reference only and shall not affect the construction or interpretation of this Agreement;

1.2.3 this Agreement includes the Schedule which is incorporated herein and will be deemed to have effect as if the provisions of the Schedule were fully set out herein.

2. Commencement and Term

This Agreement shall commence on the Commencement Date and shall continue in force for the Licence Term unless earlier terminated in accordance with Clause 6.

3. Licence and Improvements

3.1 The University hereby grants to the Licensee, subject to the terms of this Agreement, a non-exclusive, royalty-free licence, for the duration of the Licence Term (subject to Clause 6), to Use the Documentation, the Software and any Intellectual Property Rights therein, in the Territory, for the sole purpose of the Licensee's own academic research in the Field. For the avoidance of doubt, the Licensee is not permitted to use the Software or the Documentation for any commercial purpose whatsoever.

3.2 The Licensee hereby undertakes to submit to the University and to Dr Elizabeth Peterson a detailed outline of the circumstances including the design and methodology in which the Licensee proposes to use the Software. Dr Elizabeth Peterson has the right to refuse to license the software if she does not approve of the proposed use and circumstances.

3.3 The Licensee shall not grant or purport to grant to any third party any sub-licence or subcontract of its rights or obligations under this Agreement.

3.4 The parties acknowledge that the Licensee may make Improvements to the VICS Software and Dr Peterson's extension of the CSA-WA from time to time. For the avoidance of doubt, no amendments can be made to Dr Richard Riding's CSA-WA without Dr Richard Riding's prior permission. The Licensee shall in a timely manner notify the University of any Improvements and shall provide copies of object code and source code to the University to take account of any Improvements or other amendments to the Software. The Licensee hereby grants a non-exclusive, royalty-free, irrevocable licence in favour of the University of the Intellectual Property Rights in any Improvements for use in research and education.

3.5 The Licensee warrants and undertakes that all Intellectual Property Rights in any Improvements shall be the sole property of the Licensee and that the exercise by the University of the rights licensed to it in terms of Clause 3.3 will not infringe the rights of any third party.

Figure H2. License agreement and permission for use of Peterson's VICS and Extended CSA-WA tests, page 2.

3.6 The Licensee hereby agrees to acknowledge that the VICS Software developed by Dr Elizabeth Peterson at the University of Edinburgh was based on a verbal-imagery cognitive style test developed by Dr Richard Riding in any documentation or publication which describes Improvements which the Licensee makes to the Software, or which otherwise makes reference to the Software

3.7 The Licensee hereby agrees to acknowledge that the Extended CSA-WA Software consists of Dr Richard Riding's CSA-WA and Dr Elizabeth Peterson's extensions to this test in any documentation or publication which describes Improvements which the Licensee makes to the Software, or which otherwise makes reference to the Software.

3.8 The Licensee will promptly inform and provide a copy to the University of any Results and the Licensee hereby grants to the University a non-exclusive, royalty-free licence to use the Results for the University's own research and education purposes.

4. Intellectual Property

4.1 The Licensee acknowledges that all Intellectual Property Rights in the Software vest in and are the property of the University and that the Licensee shall, subject to Clause 4.2, acquire no rights of ownership in or to the Software.

4.2 The University acknowledges that all Intellectual Property Rights in and to any functional adaptations, additions or variations to the Software developed by the Licensee ("Improvements") shall vest in and be the property of the Licensee and that the University shall acquire no rights of any nature in such Improvements, save as provided in Clause 3.4.

4.3 If the Licensee detects or suspects any infringement of the University's Intellectual Property Rights in the Software or misappropriation or misuse of the Software, he shall promptly notify the University and provide all details within its knowledge with respect to the same and shall provide the University with all assistance requested by the University for the purposes of any action brought by the University with respect to any such infringement, suspected infringement, misappropriation or misuse.

5. Confidential Information

5.1 Both parties hereby agree and undertake that they will keep confidential all, and will not use for their own purposes nor without the prior written consent of the other disclose to any third party any, information of a confidential nature which may become known to such party from the other party and which relates to the other party, except to the extent that the receiving party can prove that the information:

(a) has become public knowledge other than through an unauthorised disclosure by the receiving party;

(b) was in the possession of the receiving party in recorded or other verifiable form prior to disclosure being made to them;

(c) was disclosed to the receiving party by a third party not under an obligation of confidence to the disclosing party with respect to the information;

(d) was independently developed by an employee of the receiving party who did not have access to the information; or

(e) is required to be disclosed by law or by a requirement of a regulatory body.

5.2 The provisions of this Clause 5 shall remain in full force and effect notwithstanding any termination of this Agreement.

Figure H3. License agreement and permission for use of Peterson's VICS and Extended CSA-WA tests, page 3.

6. **Termination**

This Agreement may be terminated by the University immediately by written notice to the Licensee if the Licensee is in material breach of this Agreement and either that breach is incapable of remedy or the Licensee shall have failed to remedy that breach within 30 days after receiving written notice requiring him to remedy that breach.

7. **No Warranty**

7.1 The University makes no warranty, representation or guarantee of any kind, either express or implied, including but not limited to, any implied warranties of quality, merchantability, fitness for a particular purpose or ability to achieve a particular result. The Licensee assumes the entire risk as to the quality and performance of the Software.

7.2 Except in respect of personal injury or death caused directly by the negligence of the University, in no event will the University be liable for any damages, including any lost profits, or any indirect, special or consequential losses arising out of the use of the Software.

8. **Entire Agreement**

This Agreement constitutes the entire understanding between the parties with respect to the subject matter hereof and supersedes any previous understandings, arrangements, representations, negotiations or agreements previously entered into between the parties. Provided that nothing in this Clause 13 shall have effect to exclude the liability of either party for fraud or fraudulent misrepresentation.

9. **Waiver**

Failure, delay or neglect by either party to enforce at any time any provision of this Agreement shall not be construed nor shall be deemed to be a waiver of that party's rights hereunder nor in any way affect the validity of the whole or any part of this Agreement nor prejudice the party's rights to take subsequent action.

10. **Severability**

If any provision of this Agreement is declared to be void or unenforceable by any judicial or administrative authority in any jurisdiction in which this Agreement is effective, such provision will be deemed to be severable and the parties shall each use their reasonable endeavours in good faith to modify this Agreement so that the intent of this Agreement can be legally carried out.

11. **Assignation**

Neither party shall be entitled to assign transfer or sub-contract any of its rights or obligations under this Agreement without the prior written consent of the other party, provided always that the University may assign its rights under this Agreement (including its rights of assignation or nomination) at any time to any company which is from time to time to any group company of the University.

12. **Variation**

This Agreement shall not be amended and no variation to its terms shall be effective unless such amendment or variation is in writing and is signed by or on behalf of each of the parties.

13. **Notices**

All notices, requests and other communications to the University hereunder shall be in writing and shall be deemed to have been duly given if addressed, and delivered by hand, or facsimile, and confirmed by registered or recorded delivery mail, to the addresses set forth below, or to such other addresses as may be given by written notice:-

Figure H4. License agreement and permission for use of Peterson's VICS and Extended CSA-WA tests, page 4.

FAO: Director of Research & Commercialisation
Edinburgh Research & Innovation Limited
1-7 Roxburgh Street
Edinburgh EH8 9TA
Tel: +44 (0)131 650 9090
Fax: +44 (0)131 650 9031

Copied to: Dr Liz Peterson
RCITL
The University of Auckland
Private Bag 92019
Auckland
New Zealand
Tel: +64 9 373 7599 extn 89693/82013
Fax: +64 9 367 7191
E-mail: e.peterson@auckland.ac.nz

14. Applicable Law

This Agreement shall be governed by and construed in accordance with the law of Scotland and the parties hereby prorogate the exclusive jurisdiction of the courts in Scotland.

IN WITNESS WHEREOF this Agreement comprising this, the previous six pages and the Schedule annexed hereto, is executed as follows:

For and on behalf of The University Court of The University of Edinburgh:

Signature:

Name: Derek Waddell

Title: Director of Research & Commercialisation

Date: 26 March 2007

Witnessed by:

Signature:

Name: RACHEL TERESA WELLS

Address: 1-7 ROXBURGH STREET
EDINBURGH EH8 9TA, UK

For and on behalf of John Murdoch:

Signature: John B Murdoch

Date: 30 March 2007

Witnessed by:

Signature:

Name: Adam A. Snyder

Address: 2912 N. Central Dr.
Chandler, AZ 85224
USA

PSYCHOL009. Licence Agreement. VICS & Extended CSA-WA. 26.03.07 Page 5 of 6

Figure H5. License agreement and permission for use of Peterson's VICS and Extended CSA-WA tests, page 5.

This is the Schedule referred to in the foregoing Licence Agreement between The University Court of the University of Edinburgh and John Murdock

SCHEDULE

THE SOFTWARE

The VICS Test

The Verbal Imagery Cognitive Styles (VICS) Test is a computerised test designed to measure an individual's cognitive style preference for processing information verbally or by using pictures or images.
The VICS Test assesses verbal-imagery style preferences by comparing the time taken to answer questions about whether two objects are natural or manmade (verbal task) with the time taken to answer a question about the relative size of two objects (imagery task). The ratio of the participant's average verbal task reaction time to their average imagery task reaction time is calculated and the value of this ratio is used to indicate the individual's place on a verbal-imagery style preference continuum.
The objects used in the VICS Test's verbal and imagery tasks are presented in both a picture and a word format and the same objects are used in each both tasks so that the only difference between the verbal and imagery tasks is the type of question being asked.

The Extended CSA-WA Test

The Extended Cognitive Styles Analysis – Wholistic-Analytic test (Extended CSA-WA) is a computerised test designed to measure an individual's cognitive style preference for structuring information in a wholistic (global) or an analytic (local) way.

The Extended CSA-WA is an extended version of Riding's (1991) wholistic–analytic dimension of the Cognitive Style Analysis (CSA) test. That is, the first half of the test contains Riding's original wholistic-analytic items from the CSA and the second half of the test contains a novel set of wholistic and analytic items.

The Extended CSA-WA assesses wholistic-analytic cognitive style by comparing the time taken to answer whether two complex shapes are identical, to the time taken to answer whether one simple shape is embedded in a more complex shape.

The ration of the participants' average wholistic task reaction time to the average analytic task reaction time is calculated and the value of this ratio is used to indicate the individual's place on a wholistic-analytic continuum.

Riding, R. (1991), *Cognitive Style Analysis – CSA Administration*, Birmingham: Learning & Training and Technology.

PSYCHOL009. Licence Agreement. VICS & Extended CSA-WA. 26.03.07 Page 6 of 6

Figure H6. License agreement and permission for use of Peterson's VICS and Extended CSA-WA tests, page 6.

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CONDITIONAL USE AGREEMENT

For good and valuable consideration, the receipt and legal sufficiency of which are hereby acknowledged, I hereby agree that the permission granted to me by the Hay Group (“Hay”)to receive and utilize, without charge, the Kolb Learning Style Inventory (“LSI”)is subject to the following conditions, all of which I hereby accept and acknowledge:

1. I will utilize the LSI for research purposes only and not for commercial gain.

2. The LSI, and all derivatives thereof, is and shall remain the exclusive property of Hay; Hay shall own all right, title and interest, including, without limitation, the copyright, in and to the LSI.

3. I will not modify or create works derivative of the LSI or permit others to do so. Furthermore, I understand that I am not permitted to reproduce the LSI for inclusion in my thesis/research publication.

4. I will provide Hay with a copy of any research findings arising out of my use of the LSI and will cite Hay in any of my publications relating thereto.

5. To translate the LSI, I need specific permission from Hay. If permission is granted, I will use the translation for my research only, and I am not permitted to include this translation in my thesis/research publication.

6. Hay will have no obligation to provide me with any scoring services for my use of the LSI other than the Algorithm used to score results.

7. Hay will not be deemed to have made any representation or warranty, express or implied, in connection with the LSI, including, but not limited to, the implied warranties of merchantability and fitness for a particular purpose.

8. My rights under this Agreement are non-transferable and non-exclusive and will be limited to a period of two (2) years from the date of this Agreement.

9. Hay may immediately terminate this Agreement by giving written notice to me in the event I breach any of this Agreement’s terms or conditions.

10. This Agreement will be construed in accordance with the laws of Massachusetts without recourse to its conflict of laws principles.

11. This Agreement may not be assigned by me without the prior written consent of Hay.

Figure H7. License agreement and permission for use of the Kolb Learning Style Inventory, page 1.

HayGroup®

12. Failure by Hay to enforce any provisions of this Agreement will not be deemed a waiver of such provision, or any subsequent violation of the Agreement by me.

13. This is the entire agreement with Hay pertaining to my receipt and use of the LSI, and only a written amendment signed by an authorized representative of Hay can modify this Agreement.

Agreed and understood:

John B. Murdock	John B. Murdock	3/13/07
Signature	Print Name	Date

Figure H8. License agreement and permission for use of the Kolb Learning Style Inventory, page 2.

APPENDIX I

COPYRIGHT PERMISSIONS

Table I1 Copyright Permissions

Figure/ Table	Pg.	Author	Licensor	License details
Figs. 1-3		Murdock, 2011	N/A	Owned by author
Fig. 4	25	Ertmer & Newby, 1993	RightsLink	Licensee: John B Murdock License Date: Jun 25, 2011 License Number: 2696101017904 Publication: Performance Improvement Quarterly Title: Behaviorism, Cognitivism, Constructivism: Comparing Critical Features from an Instructional Design Perspective
Fig. 5	26	McCown, Driscoll & Roop, 1996	Pearson Education	You have our permission to include content from our text, *Educational psychology: a Learning-centered approach to classroom practice*, 2nd Ed. by McCown, Rick R.; Driscoll, Marcy P.; Roop, Peter Geiger, in your Master of Science in Design (MSD), in Visual Communication Design dissertation at Arizona State University. Thesis title: “Predictors of Transitional Phase Success in Visual Communication Design Education” – Cheryl Freeman, Permissions Administrator
Fig. 6	27	Driscoll, 1994	Pearson Education	You have our permission to include content from our text, *Psychology of learning For instruction*, 1st Ed. by Driscoll, Marcy P., in your Master of Science in Design (MSD), in Visual Communication Design dissertation at ARIZONA STATE UNIVERSITY. Thesis title: “Predictors of Transitional Phase Success in Visual Communication Design Education” – Cheryl Freeman, Permissions Administrator
Fig. 7	28	Murdock, 2011	N/A	Owned by author
Fig. 8	42	Murdock, 2011	N/A	Owned by author

Note: CCC = Copyright Clearance Center

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Table 1	42	Riding & Douglas, 1993; Yukhina, 2007	Yukhina/ CCC	Ellina Yukhina: 7/1/2011 “Hi, table 1 is my synopsis of the work by Riding & Douglas with some of the terminology made more generic... Feel free to use it, I don’t mind, E.” CCC: Confirmation Number: 10415062 Order Date: 06/21/2011 Order detail ID: 55176496 Order License Id: 2693840656201 Article Title: The effect of cognitive style and mode of presentation on learning performance Author(s): Riding, Richard DOI: 10.1111/J.2044-8279.1993.TB01059.X Date: May 13, 2011 ISSN: 0007-0998 Volume: 63 Issue: 2 The British journal of educational psychology Permission Status: Granted
Fig. 9	45	Peterson, Deary, & Austin, 2003	Pergamon/ CCC	Order detail ID: 55176580 Order License Id: 2693861371520 Article Title: The reliability of Riding’s Cognitive Style Analysis test Author(s): Peterson, E. DOI: 10.1016/S0191-8869(02)00116-2 Date: Apr 01, 2003 ISSN: 0191-8869 Volume: 34 Issue: 5 Publisher: Pergamon Author/Editor: International society for the study of individual differences Permission Status: Granted

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Fig. 10	48	Peterson, Deary, & Austin, 2003	Pergamon/ CCC	Order detail ID: 55177526 Order License Id: 2694351038477 Article Title: A new measure of Verbal–Imagery Cognitive Style: VICS Author(s): Peterson, E. DOI: 10.1016/J.PAID.2004.08.009 Date: Apr 01, 2005 ISSN: 0191-8869 Volume: 38 Issue: 6 Publisher: Pergamon International society for the study of individual differences Permission Status: Granted
Fig. 11	51	Demirbas & Demirkan, 2003	Elsevier/ CCC	License number 2667151319426 License date May 13, 2011 Publication: Design Studies Title: Focus on architectural design process through learning styles Author: Demirbas, O. O., Demirkan, H. Licensed content date September 2003 Volume: 24 Issue: 5
Table 2	53	Murdock, 2011	N/A	Owned by author
Fig. 12	68	Roberts, 2006	Pergamon/ CCC	Order detail ID: 55181203 Order License Id: 2694351040024 Article Title: Cognitive styles and student progression in architectural design education Author(s): Roberts, A. DOI: 10.1016/J.DESTUD.2005.07.001 Date: Mar 01, 2006 ISSN: 0142-694X Publication: Design Studies Volume: 27 Issue: 2 Publisher: Pergamon Author/Editor: Design Research Society

Note: CCC = Copyright Clearance Center

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Fig. 13	77	Demirbas & Demir-kan, 2003	Elsevier/ CCC	License number 2667151319426 License date May 13, 2011 Publication: Design Studies Title: Focus on architectural design process through learning styles Author: Demirbas, O. O., Demirkan, H. Licensed content date September 2003 Volume: 24 Issue: 5
Fig. 14	79	Kvan and Yunyan, 2005	Pergamon/ CCC	Order detail ID: 55181636 Order License Id: 2694411390187 Article Title: Students' learning styles and their correlation with performance in architectural design studio Author(s): KVAN, T DOI: 10.1016/J.DESTUD.2004.06.004 Date: Jan 01, 2005 ISSN: 0142-694X Publication: Design Studies Volume: 26 Issue: 1 Publisher: Pergamon Author/Editor: Design Research Society Permission Status: Granted
Fig. 15	81	Kvan and Yunyan, 2005	Pergamon/ CCC	Order detail ID: 55181636 Order License Id: 2694411390187 Article Title: Students' learning styles and their correlation with performance in architectural design studio Author(s): KVAN, T DOI: 10.1016/J.DESTUD.2004.06.004 Date: Jan 01, 2005 ISSN: 0142-694X Publication: Design Studies Volume: 26 Issue: 1 Publisher: Pergamon Author/Editor: Design Research Society Permission Status: Granted

Note: CCC = Copyright Clearance Center

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Fig. 16	85	Kolb & Kolb, 2005	Experience Based Learning Systems, Inc./Hay Group Inc.	“I spoke with my supervisor and you have our permission to use the image in your research paper. Please source it appropriately (as you did below) and use the copyright on the manual. also please add the statement ‘printed with permission from Hay Group Inc’.” – Polly Finch, Customer service and sales representative, HayGroup, Inc.

Note: CCC = Copyright Clearance Center